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THE WEASELS OF NEW YORK*

THEIR NATURAL HISTORY AND ECONOMIC STATUS

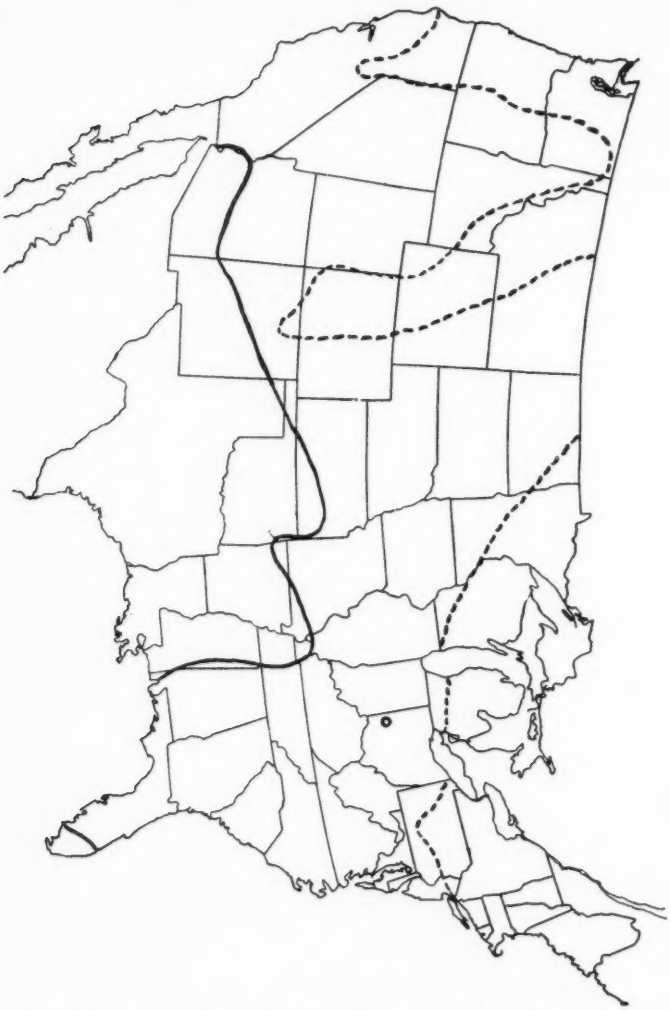
W. J. HAMILTON, JR.

INTRODUCTION

The paucity of published information regarding our small mammals is amazing. Details of their lives, which can readily be determined by careful study, has not met the proper attention which this highest class of vertebrates deserves. Perhaps with no American mammal is this more true than with the weasels. Occurring in one form or another in every state of the Union, they have been almost entirely overlooked by mammalogists, except those bent on amassing a series of conventional skins for museums. Taxonomic studies are laudable and most necessary, but the amassing of collections has now reached a stage where we might well forsake such pursuits, for a time, at least, and pursue the more fascinating and certainly as necessary, life history studies of our common mammals.

The following observations, embracing a partial and far from complete life history study, on two wide spread weasels, *Mustela noveboracensis* and *Mustela cicognanii*, have been carried on chiefly in New York. This state, possessed of three well marked life zones, is representative of many of our eastern states, and the habits of the animals detailed below will in all likelihood be found to be similar throughout the country.

* Read at the 15th Annual Meeting of the American Society of Mammalogists, Cambridge, Mass., May 10-12, 1933.



Map showing distribution of the Long-tailed Weasels (*Mustela noveboracensis* and *M. longicauda* group) and Short-tailed Weasels (*Mustela cicognanii* and its allies) in the United States. The Short-tailed Weasels range north of the broken line. The Long-tailed Weasels range north of the solid line. Undoubtedly *cicognanii* occurs in Indiana, as it has been taken at New Bremen, Ohio, twenty-five miles distance from the state border. The Map is after Seton, 1929, but slightly revised because of additional records.

DESCRIPTION OF THE NEW YORK WEASEL, *MUSTELA NOVEBORACENSIS*.

The male is a large weasel, the female much smaller (See measurements and weights). In summer the upper parts, including fore and hind feet, excepting the extremities of the toes, and often encroaching far onto the belly, dark chocolate brown. Underparts, within the same locality, white or yellow, often marked with chalcedony or straw yellow. The yellow is usually more pronounced on the sides of the throat and inguinal region.

The winter pelage over most of the northern part of the range is white, effected by a seasonal moult. This white is often suffused with yellow, notably about the throat, fore legs, inguinal region, and less so on the belly. This yellow has been ascribed to the staining of the fur by the secretions of the anal glands by some writers, inasmuch as the yellowest parts are usually those that come most in contact with these parts when the animal is curled up asleep. I cannot agree wholly with this view, for many animals that have just completed the change have far more yellow than those that have a white coat for several months.

The winter coat of brown, where the animals do not change to white, is much paler and drab than that of the summer pelage.

The tail tip is always a jet black. This black tip varies considerably in size, but never includes half the tail as Merriam has stated, (North American Fauna No. 11, p. 16). In fourteen individuals in winter dress, the black tip averages a third of the length of the tail, measuring the tail for this ratio to the end of the black hairs. The tail is quite bushy, for a weasel, in this species. The hairs, in life, are usually spread out, so the flesh of the tail is visible (Plate III, Figs. b, c, d, and e).

The sexual disparity in size is greatly marked in the New York weasel. The males average more than twice the weight of the much smaller females, and are more massive in every detail.

DESCRIPTION OF THE BONAPARTE, OR LITTLE BROWN WEASEL, *MUSTELA CICOGNANII.*

This small weasel, less than half the size of the other species, can be recognized by its much smaller tail. In summer dress, it is uniformly dark brown above, while below, including the upper lips and toes, it is white, frequently tinged with yellow. The black tail tips persists in both winter and summer pelage.

The sexual disparity in size is not so greatly marked, as in *Mustela noveboracensis.* Thirty-one males average half again as much as fifteen females (See measurements and weights).

GENERAL HABITS

Weasels are found fairly evenly distributed throughout New York State. I have seen them in the wild unsettled parts of Essex County, in the heart of the Adirondacks. In the winter of 1919-20 I trapped two large weasels in a swamp at Woodside, L. I., only five miles from Broadway and 42nd St., New York City. About central New York they are more commonly met with in swampy tracts, or the borders of such lowlands. In the winter they frequently follow the hordes of mice and rats to the towns and villages, and are even met with in sizeable cities. Mr. R. L. Arthur saw a small weasel toward dusk on the principal street of Ithaca, N. Y., early in January, 1933. It was probably hunting rats or mice, Mr. Hobart Childs of Batavia, N. Y. who handles over a thousand weasels each season, is informed by the trappers who sell him these pelts that the great majority of weasels are trapped about barns. He had not heard of any inroads they had made on poultry.

In deep snow, the tracks are often absent, but their subnivean wanderings are disclosed by some effort. During the early spring of 1932, near Ithaca, N. Y. the writer was intent on capturing some gravid woodchucks. The huge drifts of snow, during March, made shovelling about the woodchuck dens at times quite necessary. It was then I found small tunnels leading from one to the other of closely joined woodchuck burrows. They were too large for the work of mice, and too small for the work of any other mammal except weasels. Fur-

thermore, a weasel was caught in a steel trap between the terminus of one of these small burrows and the entrance to a woodchuck den at this season. In my large outdoor enclosures, weasels frequently tunnel extensively through the snow, so that a dozen openings may be made by a single animal.

Throughout the winter and early spring, at least, they travel extensively. On March 20, 1932 I followed the track of a small weasel, presumably a male *cicognanii*, for four miles in the fresh snow. In that time he made no apparent kill, but what went on inside a woodchuck hole he finally entered I do not, of course, know. During his travels he quartered here and there, now stopping to sniff at an inviting hummock of grass that might harbor a luckless mouse or shrew, then under the snow for several feet or even a rod. The tracks were well bunched, and usually in groups a foot or so apart, but when he speeded up the tracks were half again as far apart. I have known a mink to travel fifteen miles in a single night. Surely a strong *M. noveboracensis* could do half this distance without too great an effort. W. Nelson Jones, who traps the Adirondack region of New York, writes me he once spent a whole day following the tracks of a weasel, and did not get anywhere, nor did he find the weasel.

Both species develop a certain amount of fat during the winter, and the inguinal region, mesentery and kidneys are sheathed in from fifteen to twenty grams of this tissue in large weasels. I have never seen a specimen exhibit fat at any other season.

Regarding the voice, weasels have a variety of calls or notes. The most commonly heard, for both sexes and species, is a rapidly and oft repeated *took-took-took-took*. A raucous screech, not unmindful of a Blarina, but a tenfold louder, is given when the animal is alarmed or unduly disturbed. Again, the voice of a female Bonaparte Weasel, when pursued or approached by a male, is best likened to a high pitched reedy note.

A sibilant hiss, especially noticeable when the animal appears to be investigating an object, is common to all eastern weasels.

All weasels are relatively cleanly animals. Captive indi-

viduals always seek a corner in which to deposit their feces. If a large nest box is provided, the droppings are deposited in a corner of this. More often the animals leave the nest to defecate,' and this is usually a far corner, well removed from the nest.

In a period of a week, a large male *noveboracensis* averaged ten evacuations every twenty-four hours. Usually the tail is slightly lifted when the feces are passed; with females of *cicognanii* the tail is arched high over the back during this process. Urination always immediately precedes defecation. In natural tunnels and burrows of these animals, a chamber is reserved for a toilet, and this may be filled with several handfuls of droppings.

The feces are usually black or dark brown, depending on the type of food eaten. Long and narrow, they are likely to be spiral shaped, due to the matted fur of some rodent that has been eaten.

MEASUREMENTS AND WEIGHTS OF WEASELS
NEW YORK STATE

Mustela noveboracensis male adults. 19 specimens:

Total Length	Tail	Hind Foot	Weight
405 mm.	135 mm.	44.5 mm.	224.7 grams
(445-374)	(153-124)	(50-42)	(267-196)

Mustela noveboracensis female adults. 13 specimens:

Total Length	Tail	Hind Foot	Weight
325 mm.	107.5 mm.	37.1 mm.	101.8 grams
(362-306)	(117-95)	(41-34.8)	(126-71.5)

Mustela cicognanii male adults. 31 specimens:

Total Length	Tail	Hind Foot	Weight
272 mm.	70.8 mm.	34.8 mm.	81.2 grams
(295-251)	(80-65)	(38-32)	(105-66)

Mustela cicognanii female adults. 15 specimens:

Total Length	Tail	Hind Foot	Weight
236.5 mm.	54.7 mm.	29 mm.	54.3 grams
(255-194)	(65-44)	(31-28)	(71-45)

(The measurements and weights in parenthesis give the extremes for each group.)

Apparently the Bonaparte Weasels of Minnesota are considerably larger than those of New York. Bailey (1929) found the average weight of six males to be 136.5 grams; one weighed 200 grams, or almost twice as much as the heaviest male I have ever seen from New York. All his measurements for these weasels are much greater with both sexes, than those I have given for New York individuals. Might not this much greater difference in size be worthy of subspecific valuation?

NUMBERS

From letters and interviews with thirty fur buyers in western New York, I have ascertained the average number of weasel pelts an individual buyer handles per season to be 280. Most of these have been large buyers. Those that buy only dealer's lots, however, and do not purchase skins direct from the trapper, have been ruled out. Likewise those who handle in excess of 500 skins each season have not been included. Many dealers whom I have not included buy only 25 or 30 skins per season, so the average of 280 is probably high. Let us then assume that 150 skins per dealer to be a correct figure. Michigan has 600 raw fur-buyers (Dearborn, 1932), while New York, with a rural population half again as large as Michigan (1920 census), certainly has as many fur-buyers, and quite probably many more. Thus we may assume that local fur-buyers in the state handle about 90,000 skins a year, and surely another 10,000 are shipped by the trappers to the large fur houses of St. Louis, Chicago, Detroit, and New York, and to the mail-order houses.

Another way we may arrive at the catch is to determine the number of trappers and the average catch per trapper. Mr. L. E. Pierce, of Trumansburg, N. Y., has caught as high as 200 about Cranberry Lake, St. Lawrence County, N. Y., in a single season. In Tompkins County, central New York, this trapper takes from 25 to 30 during the season. P. W. Talbot, a large buyer of Binghamton, N. Y., has furnished me with the record of one trapper who lives near this city. This unusual trapper has kept records of his catch from 1924 to 1931, and averages 65 per season over an eight-year period. E. J. Dailey, of Ogdensburg, N. Y., who runs an Adirondack trap

line, informs me he catches 50 a year when prices warrant. C. N. Bowdish, of Esperance, N. Y., takes 30 each winter; H. G. Wilson, of Evans Mills, N. Y., catches 25 a season; C. J. Rulison catches 20 or more each year, while John Molinaro, of Amenia, N. Y., traps about 15 each fall and winter. Thus we have experienced trappers taking from 30 to 40 per season, but the average trapper, far less experienced than these men, naturally catch fewer animals. I have talked with a number of boy trappers, and find, of twenty questioned, the number of weasels taken is 1.7 per boy. Thus, being extremely conservative, we may rightly assume that each trapper catches one weasel a season. There are probably 75,000 trappers in New York (Michigan has 60,000), so the catch is not far from this number. If a fourth of the weasel population are taken by trappers each year, this would set the number in New York State at 300,000.

From all reports, based on personal letters and many interviews with fur-buyers, I am inclined to the belief that weasels are becoming more numerous. Certainly their ranks are not being affected adversely by the fur boom of the past few years. With the near extirpation of several forms, and the annual decrease in numbers of many of our fur-bearers, it is a pleasure to see some species not only hold its own, but increase, even though it be a weasel.

While Pennsylvania, slightly smaller than New York, pays bounties on an average of 50,000 weasels per year, it must be remembered that one species, *M. noveboracensis*, is common throughout the state. A few *rixosa* and *cicognanii* are turned in, but the large weasel predominates. In New York there are probably as many large weasels as in Pennsylvania, while *cicognanii* appears to be much commoner throughout most of the state. This would imply twice the weasel population in New York over that of Pennsylvania, and accounts for the greater number taken, in spite of the absence of an alluring dollar bounty.

As with other small mammals, weasels vary in number from year to year. Their fluctuations probably coincide with that of mice. However, in the absence of suitable food, the weasels probably move from a locality of sparse murine popu-

lation to a land of plenty. It is certain that in one region of a state, reputed to have weasels at a low ebb, another region, often not far removed, will have an abundance of the animals.

During the early summer of 1928, I was collecting small mammals in northwestern Connecticut. My catch was rearkably light, the most abundant mouse being the supposedly rare *Napaeozapus*. I talked with Hiram Beebe, of Canaan, Connecticut, a large fur buyer, who informed me the weasel catch the previous winter had been enormous, twenty times as high as usual. This may be accounted for, in part, by the greater number of trappers, induced by the lure of extravagant prices.

Probably the weasels had killed off a high percentage of deer mice, *Peromyscus*, but were unable during the winter, at least, to reach the hibernating jumping mice.

J. W. Pardee, of the West Canada Creek section of the Adirondacks, New York, informs me weasels were excessively abundant in 1928 and 1929.

H. G. Wilson, at Evans Mills, N. Y., finds that weasels fluctuate from year to year. He found them unusually abundant during the winter of 1932, but at Genoa, in central New York, Mr. Elmer Close, a fur buyer, found weasels scarce during the same period. Mr. H. R. Tucker, of Jordan, N. Y., not far from Genoa, likewise found weasels uncommon in his section. In previous years they were abundant. Ralph G. Cator, of Palmyra, N. Y., writes me that the supply of weasels he has received during the winter of 1932-33, numbering about 300, is low. In 1928 he bought nearly as many weasels as skunks. In general, about six skunks are trapped to every weasel taken. This is for New York state, and the ratio arrived at by observing many buyers' lots of raw furs in several sections of the state.

RELATIVE NUMBERS OF *M. NOVEBORACENSIS* AND *M. CICOGNANII.*

It is interesting to note the relative numbers of *M. noveboracensis* and *M. cicognanii* throughout the state. In the fur trade, a male *noveboracensis* rates as large, a female *noveboracensis* and a large male *cicognanii* as medium, while a small *cicognanii* male and female of this species are classed

as small. On this basis I have estimated the relative numbers of each species, at certain points throughout the state where I have not had opportunity to actually see the pelts in quantity. Every station, or area on the map, is represented by several hundred skins, and in some instances, a thousand or more, for the Adirondack region. In western and central New York the relative numbers are based on actual observation of trappers and buyers lots.

In western and central New York, the two species are of approximately the same numbers. From Elmira to Jamestown *noveboracensis* predominates over the smaller *cicognanii* (3 to 1). In the southern part of the Finger Lakes region, the numbers are equal (61 *noveboracensis* - 60 *cicognanii* about Ithaca) while the Bonaparte Weasel is more abundant at Canandaigua (95 *cicognanii* - 50 *noveboracensis*). Along Lake Ontario, from Buffalo to Oswego, the small form predominates, in the ratio of 7 to 5.

Along the St. Lawrence watershed, embracing Jefferson and St. Lawrence Counties, the Bonaparte outnumbers the New York Weasel by 3 to 1, but at Evans Mills, N. Y., I am informed by H. G. Wilson that he traps them in equal numbers.

Unfortunately I have not actually seen large numbers of pelts from the Adirondack region, so must rely on the written observations of many fur-buyers and trappers who have supplied me with this data.

In extreme northern New York *noveboracensis* is uncommon, but I have specimens from Malone. The Plattsburgh region has many weasels, but a dealer there writes me 80 per cent are small. At Port Henry, Essex County, over 75 per cent are the small species, while along the Mohawk River, from Troy, N. Y. to Utica, N. Y., and for an area encompassing a line fifty miles north of this, the Bonaparte apparently outnumbers the large weasel in a ratio varying from 6 to 1, at Utica, and approximating 3 to 2 at Troy. A trapper at Amsterdam informs me that they are found in equal numbers.

As we progress southward, *noveboracensis* becomes more abundant, and *cicognanii* less so. At Middletown, the small

species is far less common than its congener, *noveboracensis*, while at Amenia, Dutchess County, *noveboracensis* outnumbers *cicognanii* 7 to 3. Ninety per cent of the weasels of Westchester County are *noveboracensis*. There is a single published record of *cicognanii* on Long Island (Helme, 1902) while *noveboracensis* is quite abundant throughout the Island.

It would thus seem that the two species are fairly even in point of numbers throughout the state, but in reality such is not the case. *M. cicognanii* outnumbers *M. noveboracensis* at least 2 to 1. This ratio is based on numbers furnished me by fur buyers and trappers throughout the state.

RATIO OF SEXES

It is readily observed that males of all weasels are better represented in collections than females. This has given rise to the belief that they are far more numerous. Bangs (1896) has stated, that in examining large series of weasels, one is always struck bp the preponderance of males, outnumbering the females about 5 to 1. This ratio is far too high. In three litters of young I have raised, the males and females were equal in number. It thus appears that there is not a greater number of males than females at birth.

Several factors may account for the excessive number of males in mammal collections and fur houses. First, their size alone, especially *noveboracensis*, would be a guarantee against certain predators, such as house cats, from killing them. Secondly, the heavier weight of the males would spring a steel trap set for them, or other fur-bearers, while such a contrivance must be adjusted very delicately to catch a female of *cicognanii*, which weighs little more than a large meadow mouse. I have actually seen the female of this latter species repeatedly jump over a steel trap, carefully set on edge, at the mouth of the burrow she was occupying. Thirdly, among the small Bonaparte weasels, the female is often discarded by the trapper, especially if she be a grayback, as being of too little value (about five cents) to warrant skinning.

Among half a thousand carcasses of weasels I have handled in the past few years, together with over a thousand pelts noted, there is a disparity in the ratio of the sexes, but

it may be explained by any or all of the above suggestions.

In large numbers of *M. noveboracensis* as raw pelts and carcasses, the males outnumber the females approximately 3 to 1. In the smaller *cicognanii,* the males outnumber the females 2 to 1. It must be remembered, however, that about 95 per cent of the weasels taken by trappers are caught in steel traps set for skunk, and the diminutive female of the Bonaparte seldom brings enough pressure on the pan of the trap to spring it. The small animals, when caught, are usually taken about the middle, and not by the foot, indicating it was the weight of the entire body that sprung the trap. If the animals are caught in box traps, the sexes are more nearly equalized. Indeed, Mr. C. J. Rulison, at Clay, N. Y., caught six weasels in two weeks trapping with box traps. One was a male *noveboracensis,* while five were the little females of *cicognanii.*

MANNER OF COLOR CHANGE

It is common knowledge that the spring change from white to brown is effected by a moult, but all writers are not agreed on the fall method. Some have held that the change is brought on by a moult, while others feel an actual change in the color of the existing hair takes place. Among those who hold to the former view are Seton (1909), Miller (1931) and Merriam (1886), while Coues (1877) writes he has actually seen bicolored hairs and indicates, from his researches, that the color change, at least in the fall, is not necessarily the result of a moult. Bell (1874), likewise states that the fall color change is effected by the actual change in color of the existing hair.

The matter is not hastily settled, but it is the writer's belief that the fall color change is accomplished by a moult, as is that of the spring. I have kept and observed many live weasels pass through both fall and spring color changes. After mounting large numbers of both guard hairs and the softer under fur hairs on slides, and examining them for pigment granules, I find none that exhibit a partial change from brown to white. In other words, the hair is either well pigmented, or it is without the color-producing granules.

The inception of the fall moult is usually manifested first on the belly. Dorsally it is more likely to show first as a small saddle on the back, behind the ears or on the rump. The new fur of the belly encroaches on the sides, spreading dorsally. It may even commence in the facial region with some animals. In this event, the facial vibrissae areas are the first to become brown. If several foci occur, which quite often is the case, such as a small spot of brown on the head, neck, shoulders and rump, these gradually converge in the form of a narrow streak along the dorsum. A salty appearance is given the animal. These skins are known in the trade as graybacks. Even though the moult has just commenced, or is practically complete, the fur-buyer who sees just a shade of mixture of brown and white on the animal, classes it in this category. Graybacks rarely bring more than ten or fifteen cents on the market.

In general, an area behind the ears, a small area on the shoulders and a patch on the rump retain the summer coat longest. The tail usually gets the new fur the same time as that of the rest of the pelt, in *Mustela noveboracensis*, but in *M. cicognanii* the tail is usually the first to show the incipient change from brown to white. This is usually manifested in a few white hairs immediately preceding the black tip. Strangely enough, this area on the tail is the last to show white in the spring moult, animals taken in mid-May often having a few white hairs in this region.

The Bonaparte Weasel usually commences the moult somewhat later than its larger congener, *M. noveboracensis*. The moult is effected in much the same manner.

The pattern of the moult in the spring is essentially the same as that of the fall. However, it is more likely to commence about the facial vibrissae or directly behind the ears. In spite of this area becoming brown first, frequently a small area between the eyes and the ears retain the white long after the animal has assumed the brown pelage. Bangs (1896) has alluded to this. Speaking of *M. cicognanii*, he says:

> It is rather curious that in changing back to the brown summer coat in spring (the change taking place in March or April, according to locality) the white hairs persist longer in a well defined spot between

the eyes and the front of the ears than elsewhere on the head. In the bridled weasel this spot between the eyes is a constant character, and in *P. peninsulae* the white patch in front of the ears is a constant character; and still these weasels have no white winter coat.

Finally, no set pattern may be laid down as normal for this interesting semi-annual moult. Wide variations occur in time, manner of moult and the corresponding progress of the moult. It seems probable, from observations of many captives, that the young animals in their first moult will vary more widely from the general pattern standard than older individuals.

To my knowledge, *Mustela cicognanii* becomes white in winter throughout its range. *Mustela noveboracensis*, on the other hand, becomes white only where the winters are cold. Where half of the weasels remain brown, these brown winter specimens are always males. I have yet to see a brown midwinter female *noveboracensis* from central New York.

Inasmuch as the males remain brown, it may suggest ancestry with a northern race, or long residence in the north, and not a recent invasion of *noveborecensis* into colder latitudes. This, of course, providing we accept the theory that females are closer to the primitive stock, and show better the phylogenetic characters of the race.

What induces the change? Bell (1874) has emphatically stated that temperature is the determining factor. Coues (1877) states without qualification that "temperature is the immediate controlling agent" in this change of color, and seems to think it proven because northern animals always change. Merriam (1884), on the other hand, does not regard temperature as at all important in bringing on the change, and holds that the presence or absence of snow is the immediate cause. I quote Merriam in entirety, for his statements appear so sound that without first hand knowledge of this affair, the reader is apt to regard his statements as conclusive:

> It has been my experience, and the experience of many hunters and trappers that I have consulted on this point (an experience resulting from the examination of upwards of an hundred specimens caught at about the time of the first snow) that the Ermine never assumes the white coat till after the ground is covered with snow, which is generally

late in October or early in November. It frequently happens that the temperature of the atmosphere is many degrees lower during the week or ten days preceding the first fall of snow than at, or immediately subsequent to, the time of its deposition. Notwithstanding these facts, it is equally true that Ermine caught up to the very day of he first appearance of snow bear no evidence to the impending change. Within forty-eight hours, however, after the occurrence of the snow-storm (provided enough has fallen to remain and cover the ground; and regardless of the temperature, which commonly rises several degrees soon after the storm sets in) the coat of the Ermine has already commenced to assume a pied and mottled appearance (often symmetrically marked and strikingly handsome), and the change now commenced progresses to its determination with great rapidity. In early spring, the period for the reversal of this process, the changing back from the white coat of winter to the brown of summer is determined by the same cause—the presence or absence of snow.

From these observations the reader might adduce that the question was settled, viz., that the presence or absence of snow was the only factor to bring on the change. My own observations are so different from this that I must qualify those of Merriam.

In collecting carcasses and data on weasels from many trappers and fur-buyers, I have had several very interesting notes from trappers in the Adirondack region, where Merriam carried on his classical studies. H. G. Wilson, of Evans Mills, N. Y., tells me that snow is not necessary to bring on the change from brown to white, not in the northern part of New York anyway, where some years they are pure white before a flake of snow has fallen. Mr. E. J. Dailey, who runs an Adirondack trap line, informs me that weasels are occasionally seen the first of November that are all white, long before any snow has fallen.

In central New York, where the winters are usually severe, with an occasional sub-zero spell, weasels commence to change to white from mid-October to the first of November, regardless of the presence or absence of snow. See 'Period of Fall Color Change' for further data.

Again in the spring, weasels may commence the change from white to brown when a foot of snow exists. The spring of 1932 was a striking example of this. Animals taken dur-

ing late March, when snow had covered the country for a week or two, showed advanced moulting.

What factor, or series of factors, induce the change, I am not prepared to say. It has been shown above that snow is not an immediate cause, nor is temperature an important contributing factor. In spite of Merriam's assertion to the contrary, animals kept in warm enclosures moulted as rapidly as those exposed to the vicissitudes of nature.

PERIOD OF FALL COLOR CHANGE

In general, weasels assume the white winter dress earlier in the northern part of the range than in the southern part. Animals in changing pelage may be observed throughout New York State from the first week in October until well into December.

Neither snow nor temperature appear to affect the period or rapidity of the change. Weasels customarily commence the change, at least in the eastern states, long before the first snows have fallen, and many are white before the first snowfall. In large outdoor enclosures, housing animals that had partly changed to white, the runways of which were exposed to several inches of snow on occasion, did not hasten the moult in any degree.

Temperature likewise appears to play little part in the change. As many remain brown in a given locality in severe winters as do those of mild winters. Animals kept in a heated cellar as a check on the rapidity of the moult in outdoor caged animals, show little or no difference in the period.

Mr. H. G. Wilson, at Evans Mills, N. Y., tells me that at the opening of the trapping season (November 10) a few have been caught that were entirely changed to white, but as a rule those caught at the opening of the season are graybacks. E. J. Dailey, of Ogdensburg, N. Y., informs me that some weasels become white in the high Adirondacks by the first of November, but in the lower altitudes not until November 20. George Forgette, of Troy, N. Y., has caught large numbers of weasels, and finds that around the middle of October, the greatest majority are half changed.

Captive adults of *noveboracensis*, in large outdoor cages, at Ithaca, N. Y., have shown the moult starting on October 10, 1932, while a young captive male had the change well commenced by the middle of October. Three young females of *noveboracensis*, in outdoor enclosures, showed an incipient change by November 2, 1932.

The following records, obtained from specimens seen in the flesh, are for central New York:

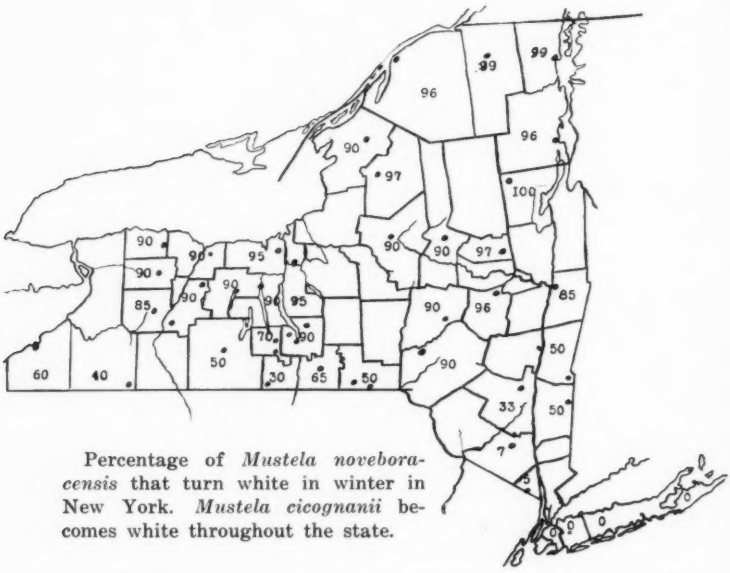
Mustela noveboracensis. November 15, 1932, a male all white; November 23, 1932, a female sparsely sprinkled with brown on the back, almost changed; a male all white. November 20, 1932, a male with small brown area on middle of back, otherwise white. November 23, 1932, a male and female, colored practically the same, both with few brown hairs on nape and rump. November 30, 1932, a male with some brown in tail, on nape and rump. December 1, 1932, a male, and December 2, 1932, two males and a female, all white. A male on December 4, 1931, all white, another male on same date with much brown over dorsal area, very broad and undivided, but tail without brown. A female on December 6, 1931, all white, while on same date, a male with brown between ears, a slight streak between shoulders, a broader streak in lumbar region and a small patch on rump. None seen after this date with brown, although some animals have a few hairs, notably about the rump, that remain blackish rather than brown, throughout the winter.

Mustela cicognanii. The small brown weasel is usually tardier than *noveboracensis* in assuming the white dress of winter. On November 27, 1932, a male with white on hind feet and some on tail, otherwise brown, was taken. The following day a female in similar condition was secured. On the same day a male, all white, was trapped, while a female had irregular brown hairs thickly scattered over the dorsal region, excepting the tail. Two males had small brown areas between the eyes and ears, the neck, shoulders and back, but only one of these had a sprinkling of brown on the tail.

A male collected on November 12, 1932 had a white head and neck, but the back and hind legs were liberally sprinkled with brown.

November 9, 1932 two males exhibited the complete change. A female taken on November 20, 1932 was all white.

December 1, 1932 a male collected proved to be entirely white, while on December 6 and 13, 1932 two males, similarly marked, retained a small brown patch on one fore shoulder and a few brown hairs on the rump. December 18 and 20, 1931 two females had completed the change.



Percentage of *Mustela noveboracensis* that turn white in winter in New York. *Mustela cicognanii* becomes white throughout the state.

PERIOD OF SPRING MOULT

The change from white winter dress to that of brown is consummated from mid-February to early May. Few commence the moult earlier than the first week of March, and the change has finally been completed by the last week of April. It

is difficult to determine the periods of spring moult, as few animals are collected by the trappers at this season. However, H. G. Wilson tells me both species retain the white coat throughout March, near Watertown, Jefferson County, N. Y.

Mustela noveboracensis. A male of this species had the moult commencing on one ear and part of the neck on March 7, 1932, while a female taken a week later had some brown on the shoulders and nape. At Ithaca, N. Y., a female on March 2, 1932, was all white, as was another Ithaca female collected a week later. A very large male collected on March 18 is practically identical with a captive in the progress of the moult. The head and face are brown, as well as a well defined area in small of back and on rump.

On April 5, 1932, a male taken near Ithaca, had completely changed but for the white tail. April 8 a female, taken at Ithaca, had a few white hairs in the tail, otherwise brown. April 27, 1932, a male still retained a few white hairs in the tail.

Mustela cicognanii. On February 13, 1932, a male was taken that showed strikingly the inception of the moult. The area about each eye, the cheeks and a broad band extending through the postocular region to the ear were brown. A narrow stripe of white separated the brown in the postorbital region. The animal was otherwise in the white winter dress.

A male collected at Clay, N. Y., has the moult just commencing on March 15. Two narrow stripes of brown, widely separated, extend down the back. A male collected April 8, 1932, at Ithaca, N. Y., has a little white remaining in the tail. A male collected at Ithaca, N. Y., on April 27, 1932, has a few white hairs remaining in the tail. A male taken at Clay, N. Y., on March 13, has the change about one-third complete.

A male killed on May 16 still retains a touch of white above the black tail tip, but its mate, taken the previous day, had completely changed to brown. Likewise a male collected on May 26, 1933 has fifty or more white hairs on the ventral portion of the tail, just above the black tip.

LENGTH OF TIME REQUIRED FOR MOULT IN CAPTIVE WEASELS

FALL MOULT

Sex	Species	Dates	No. of Days
♀ adult	noveboracensis	Oct. 21 - Nov. 23	33
♀ subad.	noveboracensis	Nov. 2 - Dec. 4	28
♀ subad.	noveboracensis	Nov. 3 - Nov. 29	26
♀ subad.	noveboracensis	Nov. 3 - Dec. 8	35
♂ adult	noveboracensis	Oct. 22 - Nov. 24	33
♂ subad.	noveboracensis	Oct. 15 - Nov. 13	29
♂ adult	cicognanii	Nov. 13 - Dec. 3	21

(all in outdoor cages)

SPRING MOULT

Sex	Species	Dates	No. of Days
♂ adult	noveboracensis	Mar. 10 - April 14	33-indoors
♂ adult	noveboracensis	Mar. 12 - April 5	24-outdoors
♂ adult	noveboracensis	Feb. 23 - April 2	39-indoors
♀ adult	noveboracensis	Mar. 22 - April 13	22-indoors
♀ subad.	noveboracensis	Mar. 7 - Mar. 30	23-indoors
♀ subad.	noveboracensis	Mar. 8 - April 2	25-outdoors
♂ adult	cicognanii	Mar. 17 - April 12	27-outdoors
♀ adult	cicognanii	Feb. 24 - Mar. 17	22-outdoors

A few white hairs may persist for weeks after the animal has practically completed the spring moult. Such occurrences are not included in the table above, for the length of the moult would then run from eight to nine weeks in some instances.

PROCEDURE OF FALL MOULT IN CAPTIVE WEASELS

In spite of the lengthy literature that has to do with the color changes of animals, I find only two reports giving details of the manner of the color change in captive weasels. One, describing the spring moult in *Mustela noveboracensis*, is by Audubon and Bachman (1849), while Miller (1930, 1931) has described both the fall and spring moult of *Mustela longicauda*. It seems advisable, thereofre, to give some attention to this phenomena, for with a number of animals we may better arrive at the *average manner* in which the change of pelage takes place.

An adult male *Mustela noveboracensis*, in an outdoor enclosure, first showed a change to white on October 23, but it

must have been apparent several days previously. At this time the snout, sides of neck in front of the shoulders, flanks, parts of the hind leg and a small area just in front of the black tail tip were white. On October 28, a large spot between the eye and ear, fore feet, flanks, most of hind feet and much of the tail are white. The sides of the animal are much lighter than along the mid-dorsal line. On the sides of the face, high up on the neck, most of the fore leg, hind leg and a good part of the tail are white. On November 5, the entire area in front of the eyes, excepting for a small supra-orbital area, are white. The back of the neck and shoulders remain very brown, but the rest of the back is heavily washed with white, giving the animal a decided pinkish cast. A small area on the base of the tail is brown. November 20 the only remaining brown is restricted to the forehead, shoulders and rump. The animal was all white four days later.

A young male *M. noveboracensis* in an outdoor enclosure first showed an incipient change on October 15, 1932. The white fur was first noticed on the entire ventral surface, and by October 20 had encroached along the flanks, the upper lips and a small facial area in the pre- and post-orbital region. The fore feet became white at this date. Three days later the entire face below the level of the eye, the larger part of the fore leg, excepting for a narrow strip of brown extending down the outer surface, and the entire upper belly and flanks had become white. The hind foot, excepting for a small area about the base of the toes, and several areas on the dorsal surface of the tail tip, are white. On October 26, a white patch of fur joins the eyes, and runs in a line along the side of the animal, extending high along the flanks. The fore and hind limbs are white, as is most of the tail. A suggestion of white appears in a small area on the middle of the dorsum, as it also does on the rump. October 28, the animal is a striking creature (Fig. 1).* In the facial region the brown is retained from the eye to snout, the old fur being heaviest on the nape and shoulders. A few patches of brown remain on the shoulders and high up on the fore limb, while the old fur is fast

See page 310.

disappearing on the rump. The tail continues to support a few brown hairs.

By November 2, the mystacial region of the face alone retains the old fur, the top of the head, back of neck and shoulders, with a bifurcating strip extending a short distance down on the body, alone being brown on the fore part of the animal. Two patches on the rump and a small area on the under surface of the hind limb are washed with brown, but the tail, excepting the black tip, is white. On November 10 the animal has only brown fur on the top of the head and back of neck. The moult is complete on the 13th.

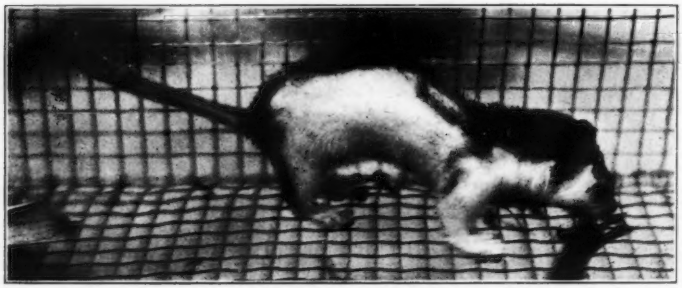


Fig. 1. *Mustela noveboracensis*, young male.

An adult female *noveboracensis*, in an outdoor enclosure, had all the belly and under surface of tail, and the dorsal surface of tail before the black tip, white. A small area remaining up behind the eye, midway between the orbit and the ear, as well as the sides of the neck, have taken on the new fur. Five days later a strip of white on the occiput, and above the eye, separates the nose, frontal region and rest of body. The old brown fur is restricted to the dorsal region. A prominent white spot, the size of a small bean, appears high up on both shoulders, while many white hairs have appeared on the dorsal surface of the tail. By November 4 the entire facial region is white, excepting a faint indication of a narrow brown line running from the nose through the eye to a point somewhat in front of, and above the ear. The entire brown summer

coat of the tail has been replaced by white. The following day the dorsal surface has a salt and pepper appearance. By November 15 a small patch of brown, liberally sprinkled with white, appears behind each ear, and the mottled rump and lumbar region indicate a few remaining hairs of the summer pelage. Four days later the animal has assumed its complete new coat. The moult commenced on October 20.

An adult male *Mustela cicognanii* in an outdoor enclosure had a small area in front of the black tail tip, as well as most of the fur on the ventral surface of the body, in new winter pelage on November 26. Three days later the tail is all white, while a sprinkling of white appears throughout the back, but more noticeably between the eyes and ears. By December 5 the entire head and a broad line running around the middle of the body is without any brown. December 10 the animal retains some brown areas over the shoulders, and a few on the rump which persists until ten days later, when it has completely assumed the pristine white of winter.

MANNER OF SPRING MOULT IN WEASELS

An adult *Mustela noveboracensis* in an outdoor enclosure first shows a change on March 12. At that time the area about the facial vibrissae, mystacial and supra-occipital, are becoming brown. A small spot, size of a large match head, midway between the eyes and ears, and in the mid-dorsal line, as well as an area directly behind the ears, together with a few hairs in the middle of the back, are brown. Three days later the entire snout, a large patch encircling the eyes and extending caudad between the ears onto the nape, are in summer pelage. The dorsal area has lengthened and broadened out, but remains rather light. On March 20 the entire dorsal surface of the face is brown. The new hairs extend some distance back of the ears, but most of the neck remains white. A broad area of the back is now rather a heavy brown. March 26 the entire dorsal surface of the animal is brown, but a small area in front of each ear remains white. This area quite frequently remains white after the animal has almost completed the change. Both fore and hind feet are getting brown hairs, but it is not until April 2 that the tail shows any brown.

All points have merged at this date, when the moult is practically completed.

The progress of the moult is not usually bilaterally symmetrical. An adult male *Mustela noveboracensis* which I collected alive and uninjured on March 15, had a small patch of brown behind the right ear, reaching a point on the mid-dorsal line to the shoulders, and proceeds down the right leg for a short distance. By March 20 the facial vibrissae, back of head and inside of ears become brown, and a sprinkling of brown hairs manifests itself along the back to the rump. March 27 pigmented hairs, and from the rump the brown encroaches for nearly an inch on the tail. By March 29 the whole face, excepting for small areas in front of the ears, are brown. This brown extends backward well onto the tail, being interrupted only on the neck by a white strip. The feet have become brown. By April 2 the only white of the dorsum is that before the ears, and a small patch just before the black tail tip.

An adult female *Mustela cicognanii* commenced the spring moult about March 25. This animal was in a cold room throughout the period of her moult. The first brown manifested was a narrow strip about two inches long on the mid-dorsal area of the back. By April 1 the nose was brown, as was two well-defined areas over each ear. The back had become well marked with brown. April 13 this brown extends a short distance down each leg, more so on the fore than the hind limbs. The face, excepting about the nose and ears, remains quite white. The moult proceeded very rapidly until April 21, when the animal was entirely brown except for a small white spot on the ventral surface of the tail, just above the black tip.

An adult female *Mustela cicognanii* in an indoor cage appears with a few brown hairs between the ears, and a few sparse brown hairs on the back and rump on March 27. This moult proceeded rapidly. By April 1 the entire dorsal surface of the animal was brown, excepting the face, which has two short brown strips above the eye, and the fore and hind limbs.

April 3 the brown has commenced to spread down the legs,

and encroaches a bit on the tail base. About the facial vibrissae a few isolated brown hairs have made their appearance. By April 8 the entire dorsal surface of the animal is brown, excepting an area just before the forepart of the body is all brown, while the rump area is but slightly sprinkled with brown. The hind legs and tail, excepting for the black tip, remain white. March 31 the animal has the general appearance of being all brown, but the rump still sprinkled with white. April 4 the weasel is all brown except for a small patch on each hind foot and the white tail. The animal was in the complete summer pelage by April 14.

I observed this animal through two spring moults, and noted that the pattern of the moult was quite different on both occasions.

A young female *noveboracensis* (ten and a half months old) shows a few dark hairs coming in at three points, namely, the nape, shoulders, and rump. These gradually merge, and nine days later the area appears peppered with brown hairs. These are thicker between and directly behind the ears. A light, very narrow, brown line runs from each eye caudad. The nasal area is brown. By March 26 the entire upper surface of the animal was brown, excepting the white tail, which gives a striking appearance to the weasel. The change was complete by April 7. This weasel was kept in a heated cellar. Moulting commenced March 7.

An adult male *Mustela cicognanii* in an outdoor enclosure commenced the moult on March 17. At this time a small spot over each eye, about the mystacial vibrissae and behind the right ear, as well as a few hairs on the neck and rump, directly on the mid-dorsal line, are brown. By March 20 the area behind the ear has spread toward the left, and involves both ears. The spots above the eyes have lengthened, extending caudad half way to the ears. The nasal areas, a line between them and encompassing the eyes and a wide area behind them to the ears, are brown on March 24. At this date the back is broadly covered with the black tip and the facial region. This latter still has the general appearance of being white, and gives a unique and rather odd look to the animal. On April 15 the animal retains white on the face from a line running

through the eyes, and another through the cephalic portion of the ears, except for two lines of brown, still narrow, that connect the eyes with the ears.

An adult male *Mustela cicognanii*, in an outdoor cage, has two faint lines of brown, widely separated, but parallel along the back, on March 15. Three days later a small patch of brown appears on the forehead, while a small spot of brown has come in on each side of the two lines of brown of the back, near their cephalic inception. A few brown hairs have made their appearance on the tail. By the 22nd these strips along the back have become much broader, but are still rather widely separated from one another. On March 23 a small spot of brown appears over each patch of mystacial vibrissae, the brown area of the forehead has widened and includes the eyes and the ears, while a tiny streak of brown shows itself in a point midway between the ears and slightly caudad to these. While the two broadening areas of brown along the back are still markedly separated, a patch, like a thick inverted Y has made its appearance between the shoulders. By March 29 the animal appears as in Plate IX, Fig. i. On April 7 the strikingly marked weasel has a line of white, about 4 mm. wide along the mid-dorsal line, while the cheeks and some of the tail are white. The animal escaped at this time.

ENEMIES OF WEASELS

INTERNAL PARASITES

Apparently internal parasites of macroscopic size are not common. I have seen both roundworms and flatworms in both species of weasels, but have not had them identified.

EXTERNAL PARASITES

Weasels are much addicted to fleas. I have found *Ceratophyllus vison* in large numbers on them while another *Ceratophyllus sp.* and *Neopsylla sp.* are not uncommon, but not as abundant as the first named. The ever present woodchuck tick, *Ixodes hexagonus*, var. *Cookei* finds a host in *Mustela noveboracensis.*

VERTEBRATE ENEMIES

Among the larger enemies, reptiles, birds and mammals account for their share of weasels. Surface (1906) records

weasels from the stomach of a blacksnake, *Elaphe obsoleta.*

Raptorial birds kill large numbers. Fisher (1893) records finding weasel remains in the stomach of the Rough legged Hawk, Goshawk and Barred Owl. Green (1930) found a *M. noveboracensis* in the nest of a Great horned Owl.

Cats kill them not infrequently. I remember, as a boy on a Massachusetts farm, the half eaten remains of a weasel brought to the doorstep by a cat. R. L. Brown of Ithaca, N. Y. recalls seeing his cat with a weasel several years ago. Mrs. E. S. Kelsey of Interlaken, N. Y. sent me a Bonaparte weasel she had taken from her cat in November.

BREEDING HABITS

The breeding habits of weasels have long been shrouded in mystery. Little published information can be found anywhere, either in this country or abroad.

GESTATION PERIOD

Many books and journals of natural history, referring to this period in weasels, state it to be 42 days. No experimental data is at hand to confirm this. However, the statement seems almost justified, when we consider the period of the ferret, a closely allied form, to be six weeks.

Definite proof of a much longer period is now at hand. On February 20, 1933, I collected a female *M. noveboracensis.* This animal was kept from all others, and on May 1, 1933, gave birth to seven young. This would make the gestation period at least 70 days.

A female *cicognanii,* collected on February 7, was allowed to run with a male from March 2 to the 10th, but I am quite sure a mating was not consummated during that period. Young were born to this female on April 24, which makes the period at least 77 days.

Brehm (1922), speaking of *Mustela ermines* says: "The period is at least 74 days; of a pair in the Berlin Zoological Gardens, the male died on February 11, 1904. The female brought forth 13 young on April 26, 1904."

I am of the opinion that weasels may have a long gestation, similar to the nine months period of the marten. Males do

not have enlarged testes until late in March or April, and the descended gonads become still more pronounced in May and June. This may indicate that mating occurs during the summer months, after the family duties are somewhat relieved. At the present time studies are in progress to ascertain more closely the approximate gestation period of these mustelids.

The young are brought forth in an underground nest from mid-April until the second week in May, in the northern states. The observations of Winecoff (1930) on the Least Weasel in Pennsylvania, indicate the young may be born in the fall or even winter months.

DESCRIPTION OF YOUNG

The following observations are from data secured from two litters of *Mustela noveboracensis* born in 1932, and one in 1933, and a single litter of *M. cicognanii* born in 1933. The two species differ widely in appearances when young, the smaller Bonaparte Weasel being possessed of a well developed mane at two weeks, while such a condition does not exist in *Mustela noveboracensis*.

MUSTELA NOVEBORACENSIS

AT BIRTH

A captive female gave birth to six young shortly before midnight on April 21, 1932. At 8:00 P. M. of this day the animal was fed, at which time she did not appear restless. Four hours later a deer mouse was put in the cage, and the weasel ran from its next box in pursuit. A young one, just born, was torn loose from her, taking with it a small piece of the placenta attached to the inch long cord. After catching the mouse and taking it into the nest chamber, the mother returned and ate the placents, then carried the young one back into the nest. The eating of the placenta probably aids in the production of milk, as shown by Hammett (1918) for man. In the meantime, the young animals in the nest had been squeaking lustily, their voices surprisingly strong for such immature animals.

The young, as I observed it the half minute it lay in the open a few inches from my eyes, was pink and much wrinkled. The wetness of the recently born animal did not entirely ob-

scure a few sparse, rather long, white hairs that appeared over its back and head. It had the pronounced and extraordinary long neck of the adult.

ONE DAY

The young are covered with a fine white hair, rather long, that does not entirely conceal the flesh colored body. The legs and tail are rather free of this fur, as is the belly. The vibrissal areas of the facial region are prominent, and have the appearance of warts. The eye is seen only as a small darkened area, deep under the unopened lids. The external ear has not unfolded. The continuous squealing of the young, when disturbed, are not unlike that of kittens.

No sexual disparity in size is apparent at this age. A male has the following measurements: T. L. 65; T. 13; H. F. 7. The average weight of six was 3.1 grams, or less than twice as much as a new born deer mouse. (Plate VI, Fig. A).

ONE WEEK

The young are pink, but covered with a white, fuzzy hair (except the belly) that obscures the skin pretty well. While they roll about vigorously, they cannot crawl. There is yet no sexual difference, in two litters, between six males and six females. The nose pad and fore claws are light brown, while the total length of the lot averaged 87 mm.; a male measures, T. L. 92; T. 21; H. F. 11. The average weight of twelve is 7.6 grams, but the largest male weighs 9.2 grams. The hair is the same length over the whole dorsal area, and does not sho wany suggestion of a mane, so pronounced in *cicognanii* at this age. (Plate VI, Fig. B).

TWO WEEKS

The silky white hair is very evident. This growing density of the fur obscures the general flesh color of the skin, evident a week earlier. The hair on back of head and neck, also over the shoulders, is slightly longer than that of the back, but no prominent crest. The ears are slightly pigmented brown. No teeth are through the gums.

The males are now readily separated from the females by size alone. The combined weight of the litter, at 86 grams,

nearly equals that of their mother's. Five males average 17 grams apiece, while the females average but 13.5 grams. The males have a total length of 100 mm. while the females average 89 mm. At this age, the young are quite strong, and can support theselves on their legs, although any attempt on the part of the young females at walking results in ludicrous failure. The males, on the other hand, can crawl along reasonably well, and journey from the nest box to the open cage on occasions. A continued squealing, when exposed to light or unduly disturbed, sounds much like that produced by young kittens. (Plate VI, Fig. C).

THREE WEEKS

The young animals are well furred over the back, the white natal becoming rather gray. A sharp line of demarcation separates the fur of the back and sides from the bare flesh-colored belly. The tail tip is black, colored by the pigmented hairs that are pushing through. The mystacial and superciliary areas are marked by large wart-like protuberances. There is no suggestion of a mane at this period. The males have an average weight of 27 grams; the females, 21 grams. The males have a total length of 150 mm.; the females are 127 mm.

The youngsters are most noisy at this age, and can roll and crawl about with agility. On the twenty-first day, while I was feeding the adult, one of the young males hurried from the nest chamber and commenced to eat some meat. The following three days three young were attempting to eat solid food. The canine and carnassial premolars are through, but the incisors have not made their appearance. When asleep, the young assume a characteristic pose. The fore legs are folded on the breast, the head drawn far back toward the inguinal area, so the young form a little ball. If they are straightened out, the animals go into such a position immediately. (Plate VI, Fig. D.)

THREE AND A HALF WEEKS

They are all eating small pieces of meat, the pieces being the size of a blowfly. The canine teeth have made their appearance in both the upper and lower jaw, but just a hint of the in-

cisors show. Some of the cheek teeth are through, as the meat appears to be thoroughly masticated by the little ones.

FOUR WEEKS

Increased activity is evident. After eating, the young immediately go to sleep. This may occur in the nest chamber, where they huddle together, or outside, where various peculiar attitudes are assumed in sleep. Sometimes the young ones lie on their bellies, again on their sides, and not infrequently on their backs, the nose pointing skyward and the feet elevated. At times, the head is brought back to the flanks, the animal almost doubling on itself. Their voices have progressed with age, and the *took-took-took* of the adults is frequently uttered. Likewise the squeal of the parents is heard. The young will travel several feet from the nest chamber to urinate or defecate. Invariably the former process follows that of evacuation. On several occasions the mother was seen to eat the feces of the young immediately after they were voided.

The males average 38.7 grams, and have the following measurements: T. L. 211; T. 49; H. F. 28. The smaller females weigh but 30.5 grams, while their measurements average: T. L. 196; T. 47; H. F. 24. (Plate VI, Fig. E.)

THIRTY-SIX DAYS

Two of the young females have opened their eyes, while the remaining two females each have a single eye open. The following day, all had secured vision, the males being the last to do so. Usually one eye opens several hours to half a day before the other.

It is likely that this relatively long sightless period is of great value. Eating meat at three weeks, and able to walk some distance at four weeks, it is apparent that the animals might and would stray some little distance from the den while waiting for food, if they had vision.

They fight much over their food, of which they consume from half to nearly their own weight daily. When playing or fighting, one will grab another by the cheek or ear, and roll about in a spiral fashion, twisting and turning about the enclosure.

The two young males play together while the smaller females consort with one another entirely.

One was seen attempting to nurse, but the mother appears dry, and the young gave up after a desultory effort to secure milk. I believe they are quite weaned with the opening of the eyes.

The mother invariably stores food in the nest chamber. This habit is so pronounced, that she will take food from the lips of the young, much against their wishes, in order to place it in a corner of the nest box. Experience apparently does not teach her that much of the food she stores will spoil long before it is consumed. In the wild state, where the efforts of the hunting parents are evidenced by little piles of mammalian remains, the damp earth probably proves an efficient safeguard to the undue spoiling of the larder before the young have entirely consumed it.

The young continually lick the lips and mouth of the mother, especially about feeding time.

In color, they are fast approaching the summer coat of the adults, although the fur is much darker and richer in appearance. The ear margins are noticeably lighter colored than in the adults, so as to be very evident. Any semblance to a woolly coat is quite past now. During the past three days, the white fur of the belly has appeared very fast. (Plate VI, Fig. F.)

SIX WEEKS

The long guard hairs are appearing, but still remain sparse. The males have an average weight of 81 grams, while they measure 240, 65, 33. The females weigh 62 grams and measure 215, 55, 27.

SEVEN WEEKS

The males are much darker than the females, and all the young are much darker than an average adult throughout the first summer. Some of the young have sulphur colored bellies, others have a lemon tinge, while one is quite white. Occasionally an individual will have several small brown spots, across the light breast of the sternal region. The young ani-

mals can run one hundred feet at the rate of a man's average walk. They are too lively to measure, but the average weight of the males is 101 grams, equal to that of their mother; that of the females 72.5 grams.

At this age they have a "game" that is frequently played. One young will cautiously approach another, then commence a stiff-legged bucking jump about an inch high, that is reminiscent of the antics of a broncho. This is continued for three or four leaps, then a rush takes it to the other, when an ear or cheek is grabbed, and the two young go squealing and mauling one another over the ground. Their antics are strikingly similar to kittens of the same age.

Throughout the summer they continue their rapid growth, and by November the females have attained nearly full growth. Even so, the mother continues to grab them by an ear or neck and drags them, protestingly, back into the nest box when they are being fed. In the wild state, however, they have probably long since disbanded family ties.

Their appetites increase with age. A young male, eight months old, killed and ate a chipmunk weighing 85 grams in a twenty-four hour period. On another occasion half an adult house rat (105 grams) was eaten during a similar period. In early November the young male weighed 162 grams. Probably immature males in the wild state, of similar age, would weigh more.

All the young of the 1932 litter took on a white coat in their first winter, as did the mother.

MUSTELA CICOGNANII

ONE DAY OLD

The young, at first glance, appears to be naked. Closer observation shows a fine growth of white hair on the dorsal surface of the neck, extending caudad to the shoulder, being longest, (2 mm.) at this latter point. These hairs foreshadow the appearance of the pompadour that becomes pronounced during the second week. Short sparse white hairs appear over the back, but the head and rump, as well as the legs and tail, are notably free of any fur, excepting the vibrissae. These

sensory hairs are most prominent in the mystacial region. The eye appears as a small darkened swelling, while the unopened ear is represented by a slight external meatus. The prominent remains of the umbilical cord, while shrunken somewhat, measure 4 mm. in length. The general tone of the animal is flesh color.

The young animals are surprisingly strong. They lift the head high in the air, and support themselves for an instant on their fore legs, but the movements are not coordinated. A pronounced squealing is manifested when the animals are disturbed, and differs only in volume from that of *noveboracensis* at the same age. Even at this precocious age the small head, long neck and thoracic basket are typical of the adults. One never need confuse them with the young of rodents, and by their diminutive size, with any other carnivore.

The average weight of six young is 1.7 grams. This is slightly less than new born young of the deer mouse, *Peromyscus leucopus noveboracensis*, which average 1.8 grams at birth. Rather surprising, in view of the fact that an adult female Bonaparte Weasel will average three times as heavy as the adult deer mouse. (Plate VII, Fig. A.)

ONE WEEK OLD

The unopened eyes are very prominent. General color very light pink with a yellowish cast over the abdomen. The fore paws are equipped with prominent dark brown, almost black, claws. From a line midway between the ears, widening and spreading caudad almost to the shoulders, the animal is much darker. Already the silky white hairs are much longer in this region, foreshadowing the prominent mane that will appear in a week or two. The little animals are strong, and give a continuous squeaking that is indeed powerful for such a diminutive creature. This note can be heard easily at fifty feet and is remindful of the song of a vireo, with a similar pause between each call. Very birdlike in character. All trace of umbilical cord is gone. A male weighs 4.7 grams, and has the following measurements: T. L. 70; T. 10; H. F. 7.5. Sexual disparity in size is not noticeable. (Plate VII, Fig. B.)

TWO WEEKS OLD

The heavy brown mane is in marked contrast to the rest of the scantily, white furred animal. This pompadour, extending from the forehead caudad almost to the shoulders, gives the animal a ludicrous appearance. The dorsum is darker, indicating the pigmented appearance of the brown fur which will soon appear. The belly is clear pink and almost devoid of hair.

While the sexes may be easily separated by the appearance of the external genitals, little difference is manifested between the sexes as regards size alone. It will be recalled that in *novboracensis* the sexes, at this age, may be readily separated by size. However, in the adults of this larger animal, the males are twice as heavy as the females, while in *cicognanii* no such discrepancy occurs, the males being only a third or half larger than the females.

The black fore claws of the previous week are now pale brown, as are the hind claws and the nose patch. The tail tip already indicates its black tip.

The measurements of a male are: T. L. 90; T. 13; H. F. 10. Five weigh 50 grams, or an average of 10 grams each. (Plate VII, Fig. C.)

THREE WEEKS OLD

The mane is still prominent, the longest brown hairs measuring 11 mm. but the rest of the dorsal surface is becoming well furred. There is less fur between the shoulders, and the facial region, also the limbs are noticeably scant furred. Neither the eyes nor the ears have opened. A fine white hair appearing on belly.

The canine and large cutting carnassial premolars have erupted, but there is no indication of the incisors. The little weasels are now eating meat.

A male measures: T. L. 115; T. 16; H. F. 12. Average weight of four is 16.1 grams, while a female weighs 16.7 grams. It is thus evident there is no sexual disparity in size yet. (Plate VII, Fig. D.)

THIRTY DAYS OLD

The fur is long enough over the dorsal area to almost conceal the mane, which still remains somewhat longer than the surrounding fur. The tail, fore and hind limbs and cheeks are still scantily haired. The borders of the ear are very light colored, almost white, in marked contrast to the rest of the animal. The ventral surface still remains almost naked.

The upper incisors are just breaking through, while the canines and premolars are now very prominent.

A loud squeaking note is often heard from the youngsters at this age.

A male measures: T. L. 114; T. 25; H. F. 17. A female is 22 grams; four males average 25 grams. Sexual disparity in size is noticed a month after birth.

THIRTY-FIVE DAYS

All the young have opened their eyes, which are dark blue. The eyes become brown in a day or two after opening. A young female had opened one eye on the morning of the thirty-fourth day. The ears open at this age. The margin of the ear is almost white, quite striking in contrast to the uniform brown of the upper parts. The white belly fur is now appearing, but not very pronounced. It is heavier on the chin and throat. The inguinal region is still quite bare.

The mane remains the most prominent hair, but is pretty well obscured by the lengthening fur of the back. The average weight of five is 32.5 grams; a female weighs 28.2 grams, while four males are 30; 32.5; 33; and 34.7 grams. Average measurements of three males are as follows: T. L. 165; T. 38; H. F. 24.

The young are being fed on chipmunks. They consume an entire animal in 24 hours, thus eating more than half their weight in this period.

FORTY-FIVE DAYS

The brown fur of the dorsum obscures any trace of the mane, which is no longer distinct. The inguinal region is clothed in thick white fur, as is the remainder of the belly.

The males average 55 grams, almost as heavy as the 62

gram mother, but much smaller in body measurements. The young female weighs 37 grams.

The youngsters are quite active, and play with one another much after the fashion of young kittens. They are rather silent, and thus contrast sharply with the young of *M. noveboracensis*, which are at all times noisy if awake. The young weasels are keenly alive to sound, and immediately raise the head if a foreign noise disturbs them, as though they are appearing to locate the source of the sound.

Until they are nearly five weeks old, the young have fed principally on the viscera of mice, small rats and chipmunks. They eat the intestine, liver and lungs, but apparently are not strong enough to tear off the flesh from the limbs and body. If such is the case in the wild state, as I have every reason to believe, then the adults must furnish them with many mice, rats or ground squirrels daily, only a small part of which is consumed by the youngsters.

CHANGES DURING POSTNATAL GROWTH IN THE TEETH OF *MUSTELA NOVEBORACENSIS*

The adult dentition is: Incisors, 3/3; Canines, 1/1; Premolars, ½; Molars, ½ = 34.

TWENTY-ONE DAYS AFTER BIRTH

The canines and third premolars, or carnassial teeth, have made their appearance. The upper incisors appear as small white knobs below the gums.

TWENTY-EIGHT DAYS

The deciduous canines and sectorial premolars have cut the gums, and are of use in tearing up small bits of meat. In a cleaned skull, all the upper incisors, the canines of both jaws, the tiny blunt first premolar, the large sectoral third premolar and the last molar are through.

FIFTY-FIVE DAYS

The deciduous dentition is being rapidly lost, and is already replaced by most of the permanent teeth. In the upper jaw the permanent incisors are through, the milk canines

are being crowded out anteriorly by the much heavier permanent teeth, while the peg-like first premolar is likewise being replaced by a heavier permanent tooth. The roots of the sectorial and fourth molar are being lifted from the alveolar surface by the eruption of permanent premolars two and three.

In the lower jaw, the permanent incisors have appeared. The permanent canines have long since erupted. The first deciduous premolar on one side has been lost, while it is still being crowded by the erupting permanent tooth of the other side. The second deciduous premolar is nearly out, being crowded by the permanent tooth that appears through the alveolar border. The third premolar remains intact, the permanent sectorial premolar has appeared through the gum, while the tiny round fifth cheek tooth has made its appearance.

The permanent dentition is complete at seventy-five days.

Changes during growth of the skull are shown in Figure 2: A represents an animal at twenty-eight days, B at fifty-five days, C at eight months, and D a fully matured weasel. All skulls are from males of *Mustela noveboracensis*.

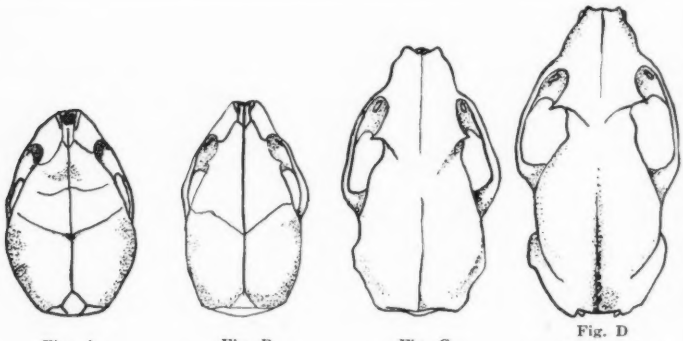


Fig. A
Twenty-eight Days.
31.5 mm.

Fig. B
Fifty-five Days.
33.5 mm.

Fig. C
Eight Months.
42.0 mm.

Fig. D
Fully adult.
Two years or more.
48.0 mm.

Fig. 2. Changes in the skull of *Mustela noveboracensis* during growth. All are males.

NUMBER OF YOUNG

It is unusual to collect females carrying young. Two litters of *noveboracensis* born by captive females numbered six and seven, while a female *cicognanii* collected on April 19, 1931, had seven fresh placental scars in the uterus. A litter of *cicognanii* I raised in 1933 numbered seven, while a family of

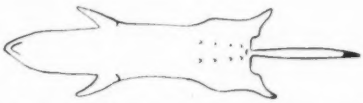


Fig. 3. Mastology of *Mustela noveboracensis*, Ithaca, N. Y., May 12, 1932. The arrangement and position are the same in *M. cicognanii*.

the same species I uncovered under a willow stump on June 26, 1926, at Wellsville, N. Y. consisted of seven very active young and the mother. Bishop (1923) found four young Bonaparte Weasels in a nest in mid-May near Albany, N. Y. Ralph G. Cator writes me that at Palmyra, N. Y., he has found three litters of six, six, and seven, and has known of one litter of nine. H. G. Wilson, tearing down an old stone wall at Evans Mills, N. Y., many years ago, informs me that he uncovered a litter of weasels, the mother and nine young ones. This was in early June, and although he thinks the young ones had not been weaned, they were nearly as large as the mother. There is no way of telling to what species these belonged. Bangs (1896) records a female *noveboracensis* and her two young, both males, together in early June at Wareham, Massachusetts. Cory records eight young of *cicognanii* in the nest, while Bailey found four young *cicognanii* in a nest in Massachusetts.

It is thus seen that the number ranges from four to nine or ten for both species, while the average number appears to be six or seven.

Each species has four pair of teats, placed in the post-abdominal and inguinal region.

RELATION OF MALE TO FAMILY

Weasels have been classed as such spiteful, unsociable

little animals that it is a pleasure to add something of a kindly nature to our fragmentary knowledge of their lives.

Regarding *Mustela cicognanii,* Bishop writes that both parents were found at the home den. Seton (1928) records three instances in which two adults were concerned in caring for the young.

On May 13, 1932, I collected a nursing female Bonaparte weasel in a woodchuck hole. The following night my trap held a male with greatly enlarged and descended testes. Presumably these were a pair.

The large *Mustela noveboracensis* likewise are to be found in pairs when caring for the young. During mid-May, 1927, I several times saw a male of this species carrying food to a den of young ones.

A few observations have been made that indicate the adults customarily pair, or at least run together, at times other than the breeding season. A pair of *cicognanii* were observed on several occasions during the winter of 1927-28. They made their headquarters under a pile of lumber adjoining the Experimental Fish Hatchery at Cornell University. During the second week of March, 1932, C. J. Rulison, of Clay, N. Y., sent me a male *noveboracensis.* He wrote "They run in pairs; there was one with the big male. The tracks were smaller, and so a female, no doubt. I will get her when she has made her rounds."

There is some reason to believe the female weasel travels but little after she becomes heavy with young. Apparently advanced pregnancy limits her venture from the home den. I have never taken but one female in an advanced stage of pregnancy, and that was at her home den. C. J. Rulison, who has supplied me with several weasels, writes that he likewise believes they travel but little the few weeks preceding parturition. While no evidence is at hand, it would be nice to believe her mate brings food to her during this period. Certainly he is not the sanguinary villain pictured by so many writers. In caged animals, with one exception, males have never attacked the females, even though strange bred females have been introduced into their cages.

FOOD

The common assumption that weasels subsist chiefly on blood, long prevalent among writers of natural history, must be discarded in the light of our present knowledge concerning these little predators. The chief item eaten, throughout the year, is small mammals, and of these mice form by far the largest share.

FALL AND WINTER FOOD

During the fall and winter of 1928, 1929, 1930, 1931 and especially 1932 the writer has examined the visceral contents of over four hundred weasels. Of those containing recognizable remains, 163 were *Mustela noveboracensis* and 191 *Mustela cicognanii*. In examining stomachs of weasels, one frequently finds them empty. Often the rectum, or some other part of the intestinal tract, will be distended with food or indigestible remains. If an incision at such a point is made, the residue of undigested matter washed into a crystal, and studied under a low powered binocular, an identification may be made. Often a few hairs, the chestnut tipped tooth of a shrew, the claws of a mouse, or the long characteristically colored hairs of a cottontail are seen, and the identification thus verified. I have outlined in a previous paper (Hamilton, 1932) the manner in which such carcasses may be collected in large numbers for such a study.

In all the fall and winter visceral examinations made, only five of the 354 which contained recognizable remains had eaten birds. Of these, three were the feathers of poultry, which may well have been chicken heads used for bait in skunk sets, while one was a tree sparrow. Several neck feathers of a grouse were found in the stomach of a male *noveboracensis*.

During the warm spell of mid-January, 1933, garter snakes ventured from hibernation and moved about. A weasel taken on January 21 had the remains of one of these reptiles in its stomach. On November 20, 1931 a male *cicognanii* was opened that had consumed a frog, *Rana pipiens*.

In a number of weasels, the hind gut was found to be crammed with hard-packed sand. This was not found only in

trapped animals, so cannot be explained as having been ingested in the animals' frantic efforts to escape. A large male *noveboracensis* that was shot by a hunter late in November and presented to me in an unskinned condition, had the rectum and part of the intestine distended with much sand. I am unable to account for this inorganic matter in a number of weasels.

SPRING AND SUMMER FOOD

Unfortunately it is not easy to secure weasels after mid-February in numbers sufficient to make indicative food studies. With the close of the skunk season, few of these animals are taken by trappers. My fragmentary notes lend some support to the statement that the summer food does not differ materially from that of the winter.

On April 5, 1932 a male *noveboracensis* was killed at Ithaca, N. Y. He had last eaten a meadow mouse. April 8, 1932 a male *cicognanii* was trapped that likewise had killed and eaten a Microtus. On May 6, 1931 a male *cicognanii* was seen carrying a *Blarina* in mid-afternoon. It was observed repeatedly by a class of thirty people. The following day, a dropping at the hole where it was last seen the previous day contained an incisor of a short-tailed shrew. A female *cicognanii* taken on May 13, 1932 had eaten a shrew, *Blarina*. Its mate was collected the following night and had chipmunk remains in the gut. During the second week of May, 1927, I saw a female *noveborcensis* carrying a meadow mouse. She was quite fearless, and allowed a noisy group of college freshmen to pass within twenty feet of her. Two days later, while birding in the early morning, I saw the male with a small rat. The home den was located under the roots of a huge elm. At this time, mid-May, the young were probably three or four weeks old, and undoubtedly demanded diurnal sojourns of the adults in search of food.

Mr. J. A. Smyth saw a weasel carrying a mouse in the afternoon of May 18, 1933 near Ithaca, N. Y. He pursued the weasel, which dropped the mouse. It proved to be a nursing *Microtus*. Bishop (1923) found the headless remains of two rats at the nest of *cicognanii* near Albany, N. Y. in mid-

May. He states that the weasel nest which was uncovered by boys, was composed partly of rat fur.

At this season, and doubtless throughout the summer, weasels feed to an uncertain, but likely small, extent on birds.

While I have yet to find a trace of insects in the viscera of weasels, Dearborn (1932) credits them with eating such. Mr. Verne Brown of Ithaca, N. Y. tells me that many years ago while he was tearing up the flooring of an old barn in midsummer, he startled a weasel from a nest. It was composed chiefly of rat fur, and would have filled a peck measure, he thinks.

Rabbits are killed throughout the summer, the young especially being preyed upon. During August, 1932 George Llano saw a weasel pursue and overpower a small cottontail near Ithaca, N. Y. Mr. E. E. Brown has likewise seen a weasel chasing a small cottontail in June. This was in North Carolina.

Abbott (1884) made some splendid contributions to our knowledge of weasels in his "A Naturalist Rambles About Home." He watched a family of *cicognanii* throughout a summer and fall. These little weasels were feeding exclusively on rats during a period in the summer. Late in the fall he found about their dens grasshoppers, crickets, frogs and mice.

Cory records a nest, presumably of *cicognanii*, that contained eight young. In or about the nest were four meadow mice. Bailey (1908) found in a nest of *cicognanii*, early in May, a yellow warbler, a song sparrow and two or three meadow mice.

Class Frequency Indices in the Fall and Winter Food of 354 Weasels (M. noveboracensis and cicognanii):

Mammals	96.7
Birds	2.1
Reptiles and Amphibia	1.2

AMOUNT OF FOOD EATEN

I have kept a number of captive weasels over long periods of time. Some of these have been enclosed in relatively spacious chambers, while others have had little room in which to

exercise. There seems to be little relative difference in the amount they eat, regardless of their activities.

In general, more food is taken in summer than in winter. Usually about a third their weight every 24 hours is eaten, but a growing young weasel will consume much more. A young male *noveboracensis*, weighing 145 grams, consumed an entire chipmunk, fur and bones, weighing 85 grams, in 24 hours. A day later it ate all of a partly grown rat, 105 grams, in the same length of time. At another time four females, all eight weeks old but very active, and weighing about 75 grams apiece, consumed 15 short-tailed shrews, the combined weight of the shrews totalling 165 grams. These were entirely consumed twenty-four hours after being fed to the weasels, which indicates the young ate more than half their weight in this period. A large rat, weighing about 300 grams, will last a male *noveboracensis* nearly three days. Weasels are capable of eating rapidly, for a male *noveboracensis* ate 40 grams of beef in eight minutes.

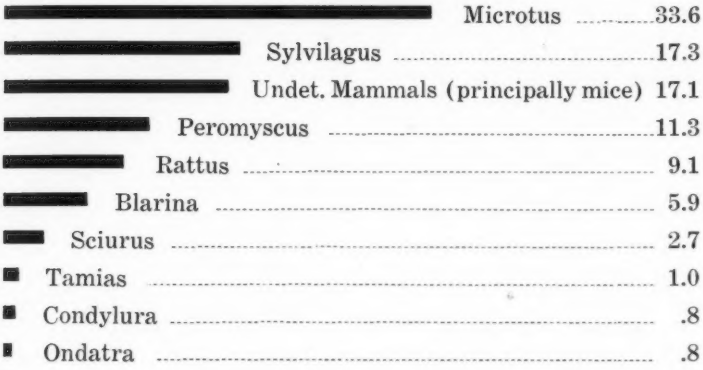
Weasels are great drinkers, and while they take but little at a time, about 25 c. c. is drunk by a large animal during a day, while more than half that amount is taken by the smaller species every twenty-four hours.

MANNER OF KILLING PREY

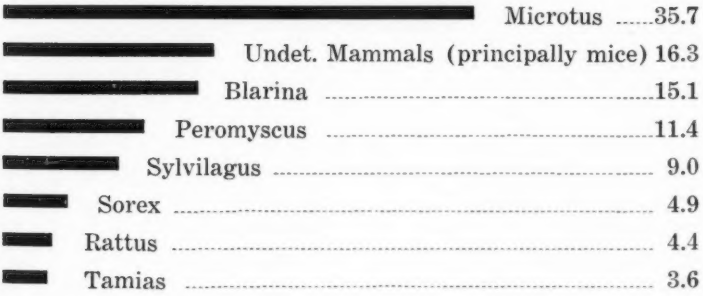
Weasels have devised a highly successful manner in the securing and killing of their catch. A rapid dash, and the bird or mouse is grabbed over the back of the skull, the fore legs encircle the animal as though hugging it, and the hind legs are brought up to scratch wildly at the captive. (Plate IX, Figs. J. K. L.) Thus the predator is free from unlikely attacks, and may securely hold the victim, if the grip must be loosened, or changed for one at a better vantage point. If a large animal, as a rat, the weasel usually lies on its side, while the diminishing struggles of the rodent continue, but if a mouse or a small bird, the weasel is apt to crouch over its prey. Little time is lost over the first, if two mice are present a strong bite through the brain case being all sufficient. If only one animal is present, the weasel dawdles over its kill some time after life has departed. Brehm (1922) has suggested that weasels probably bring living prey to their young,

but I strongly suspect that in our weasels the young never have the satisfaction of a kill until they are able to bring down game under their own prowess.

Frequency Indices of Mammal Genera in Fall and Winter Food of 163 *Mustela noveboracensis*



Frequency Indices of Mammal Genera in Fall and Winter Food of 191 Mustela cicognanii



ECONOMIC STATUS

The value of weasels as part of the raw fur crop cannot be denied. Formerly worth a maximum price of a few cents, their pelts have steadily risen in value.

In 1918 white weasels brought from $.25 to $1.00, depending on size. The following year the top price jumped to $1.75, while in 1920, the boom year for raw furs, $2.00 was paid for a large white skin. During these three years brown weasels brought a maximum of $.20.

By 1926, the price of large whites (male *noveboracensis*) was $1.75, while browns likewise brought a good profit to the trapper, selling as high as $1.50. During 1927 and 1928, trappers actually received $2.50 and $2.00 apiece for large whites and browns, respectively, while quotations ran much higher. The following year the value of all furs was reflected in unstable conditions. Since 1929 weasels have brought less each season. In 1931 large whites sold for $1.25, while small whites brought but $.25. The past season (1932-33) brown became the fashion, and for the first time in the history of the fur trade, brown weasels were worth more than the white. This change of fashion did not increase the value of the skins in any way, for the high price was $.60 for browns, while whites brought from $.40 to $.50 for large pelts. The average price was probably not in excess of $.25, for graybacks (those changing from brown to white) seldom bring more than ten cents, and frequently only five cents.

We may thus regard the average value of a weasel skin, in the trapper's hands, during the past ten years, at $.50. If one hundred thousand are taken annually in the state, this animal represents an income to the trappers of half a million dollars during that period.

The weasels greatest asset, however, does not lie in its value as a fur product. In their eternal warfare against noxious rodents, weasels perform a service to the agriculturist that is taken too lightly. In this discussion, it might be well to treat several of their chief food items separately.

WEASELS VS. RATS

By their destruction of rats alone, weasels should be held in high esteem by mankind, and more especially the farmer. An instance of an attack on the poultry yard and the subsequent killing of a few hens, by a weasel, is enough to warrant a story in any newspaper. Does the destruction of poultry

and their feed by rats ever attain such publicity? This ubiquitous rodent, the most destructive animal with which man has to contend, carries on its universal depredations without being given a second thought by most of us. I have known a rat to kill 190 chicks in a single night, and another to destroy a brood of nine is as many days, even when chased and bombarded with stones daily. Mr. Ben Rightmeyer, a farmer of Ithaca, N. Y., values the feed destroyed by a single rat in a year's time at $5.00. We may well tolerate the presence of weasels about our habitations, and not begrudge them the occasional chicken they kill, when it is known they much prefer a rat or a mouse.

Not only are rats a menace to poultry, but they undoubtedly take far more game than is commonly supposed. I captured one in the deep woods of a Canadian Zone pocket, well removed from houses, near Ithaca, N. Y. Rats spread to the fields and woods with the approach of summer, and work back to the habitations of man with the approach of frosts. Their presence in the woods is not noticed by mammal collectors, because of the small size of the traps used, and the natural wariness of the animal. Rats are seldom taken by the professional trappers in winter because of their seasonal migrations. Game breeders would do well to look to rats rather than weasels, and encourage these latter animals about their farms, as they constitute a rat trap that is never in need of setting or repairs.

WEASELS VS. MICE

The principal food of weasels, throughout the year, is mice. In New York state, the mouse most favored, or at least most accessible, and thus eaten more frequently, is the common meadow mouse (*Microtus p. pennsylvanicus*). A small weasel can consume a small mouse in a few hours; a large *noveboracensis* will eat two or three in a single night. Thus we may assume that each weasel eats in the neighborhood of three hundred mice a year, and possibly kills a hundred more. If we are again conservative, and put the number of mice killed per weasel at two hundred annually, then the 300,000 weasel population of New York accounts for 60,000,000 mice per year, and probably several million rats.

As for the destruction of rabbits, it might be well to point out that this killing is not excessive, and in the writer's locality, at any rate, rabbits can well afford to be decimated to the interest of the farmer whose peas and beans he eats, and whose young fruit trees are frequently girdled.

THE CARE OF CAGED WEASELS FOR STUDY PURPOSES

In the treatment of captive mammals, care must be taken to insure as near as possible the state of affairs in nature, in order that the animals will not be unduly disturbed. To this end, all the weasels in this study, where possible, have been kept in outdoor enclosures, in shaded woods, where diffuse sunlight reached the pens at least a part of the day.

The pens were constructed of hardware cloth, of half inch mesh. The wire in this is sufficiently heavy to retain its form on bending. To one end was attached the nest box, with hinged door. On the floor of this box sawdust, chaff or sand has been placed. This is removed at frequent intervals, and fresh material substituted. The flooring of the enclosures have been lined to the depth of an inch or so with loose soil. A half pint fruit jar for a drinking container is wired to a far corner of the cage, so arranged that it may be cleaned upon occasion.

Such an enclosure permits the animal to carry on certain features of its life that would not readily be observed in less spacious quarters kept indoors. Some of the cages have ten square feet of floor space, and are fourteen to sixteen inches high, while others are somewhat smaller. The larger cages will house a pair of adult weasels quite comfortably, or a mother and her family of growing young.

It is not likely that weasels will ever become valuable enough to warrant raising for their fur on a commercial scale, as is now done for mink. They are too plentiful and easily trapped in the wild state to tempt the fur breeder. In the event that weasel pelts again rise to a two dollar peak, it may, however, prove profitable to raise the larger forms, such as *Mustela longicauda* and *M. noveboracensis*.

There is little expense to feeding the animals. Chopped up woodchuck meat, crows, sparrows, mice and rats are eagerly eaten. Where the latter are abundant, the food problem is easily solved. Throughout the winter months they will thrive on muskrats carcasses, or even eat the meat of skunk. Indeed, weasels do not hesitate to eat the skinned bodies of their own kind. Care must be taken that too much food is not given at any one time, for the nest box will soon become filled with decomposing flesh. In the summer season especially this is apt to become a serious nuisance, for flies quickly gather at such a foul place.

Strong sunlight on the cages should be avoided. I have had adult weasels, exposed to the direct rays of a hot sun, go into convulsions in a minute or two. They quickly recover if placed on damp earth in the shade.

ZOOLOGICAL LABORATORY,
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ITHACA, N. Y.

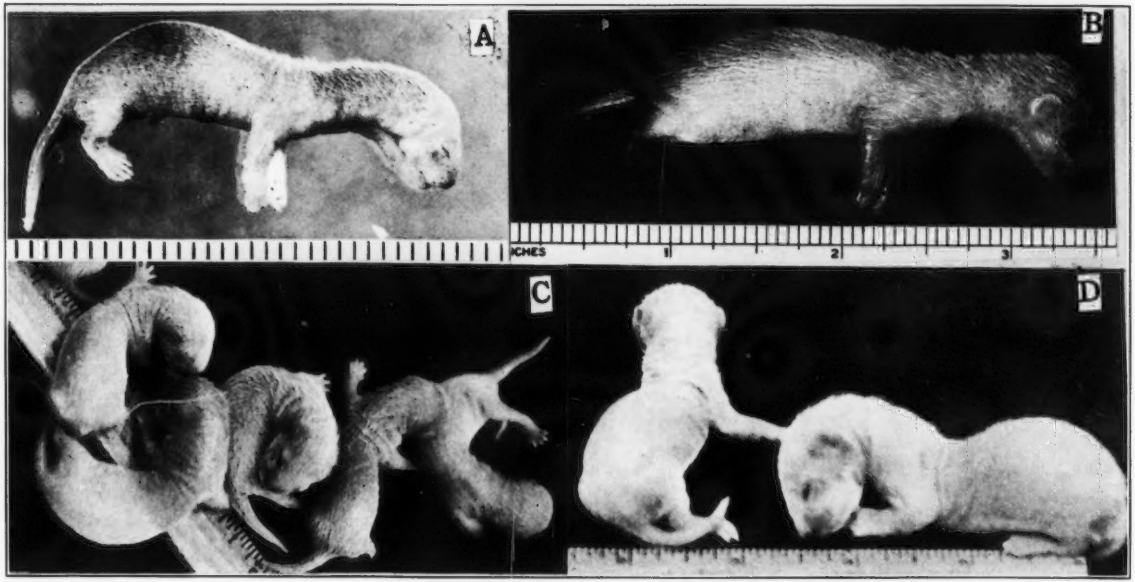


PLATE VI. Young of *Mustela noveboracensis.*

(Fig. A) One Day Old. Note the fine covering of white hair. The remains of the umbilical cord may still be seen.—(Fig. B) One Week Old.—(Fig. C) Two Weeks Old.—(Fig. D) Three Weeks Old. Sexual difference in size is now manifested. A female to the left, a male on the right.

Old.—(Fig. C) Two Weeks Old.—(Fig. D) Three Weeks Old. Sexual difference in size is now manifested. A female to the left, a male on the right.

PLATE VII. Young of *Mustela noveboracensis*.

(Fig. E) Four Weeks Old.—(Fig. F) Five Weeks Old. The animal in the middle has assumed the sleeping posture.—(Fig. G) Seven Weeks Old. Note relative size of the weasels to that of the adult chipmunk, which weighed 90 grams. The lowest animal in the picture, and that to the extreme left, are males, the rest females.

PLATE VIII. Young of *Mustela cicognanii*

Fig. A. One Day Old. The fine covering of white hair is evident. The relatively short tail and much smaller size separate this at the same age from *M. noveboracensis.*

Fig. B. One Week Old. Dark brown, almost black, nails of the fore feet are a prominent character at this age. Already the darkened area of the neck foreshadows the mane that will appear in a few days.

Fig. C. The prominent crest, or pompadour, of fur on the occiput and neck are characteristic, and differs widely from *M. noveboracensis* in this respect.

Fig. D. Thirty Days Old. The brown fur of the dorsal region is plainly visible. Note tiny black tip to tail, relatively bare legs and scant hair on facial region.

Fig. E. Thirty-five Days Old. While the picture does not show the opened eyes, this occurred in one animal the day previously, and in the entire litter on this day. The mane is fairly well obscured by the rest of the fur of the back.

PLATE VIII

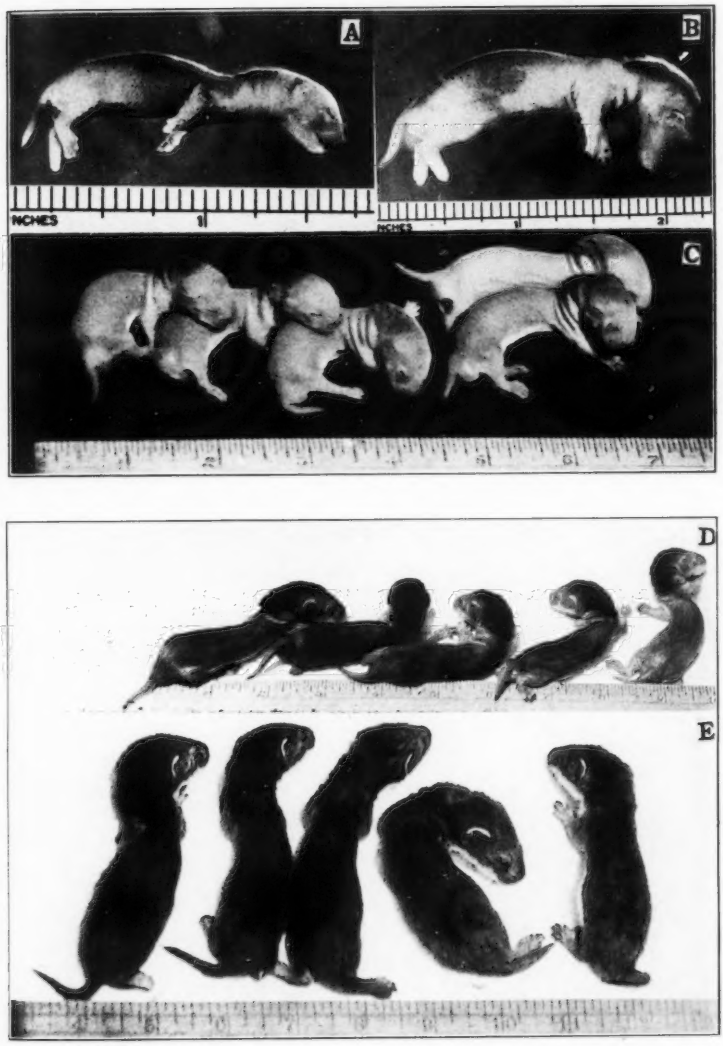


PLATE IX

Fig. a. A male *Mustela noveboracensis* showing inception of the fall moult. Ithaca, N. Y., October 28, 1932.

Fig. b. The same animal as in a, five days later.

Fig. c. The same animal as in a and b, on November 20, 1932.

Fig. d. A male *Mustela noveboracensis* at beginning of the spring moult. Ithaca, N. Y., March 15, 1933.

Fig. e. The same animal on March 29, 1933.

Fig. f. The same animal almost changed to summer coat. Note the large amount of white in the tail, which is usually the tardiest part to assume brown hairs. April 10, 1933.

Fig. g. A female *Mustela cicognanii* nine days commencing the spring moult. Ithaca, N. Y., March 25, 1933.

Fig. h. The same individual as in g, on April 13, 1933.

Fig. i. A male *Mustela cicognanii* illustrating a rather unusual spring moult pattern. March 29, 1932.

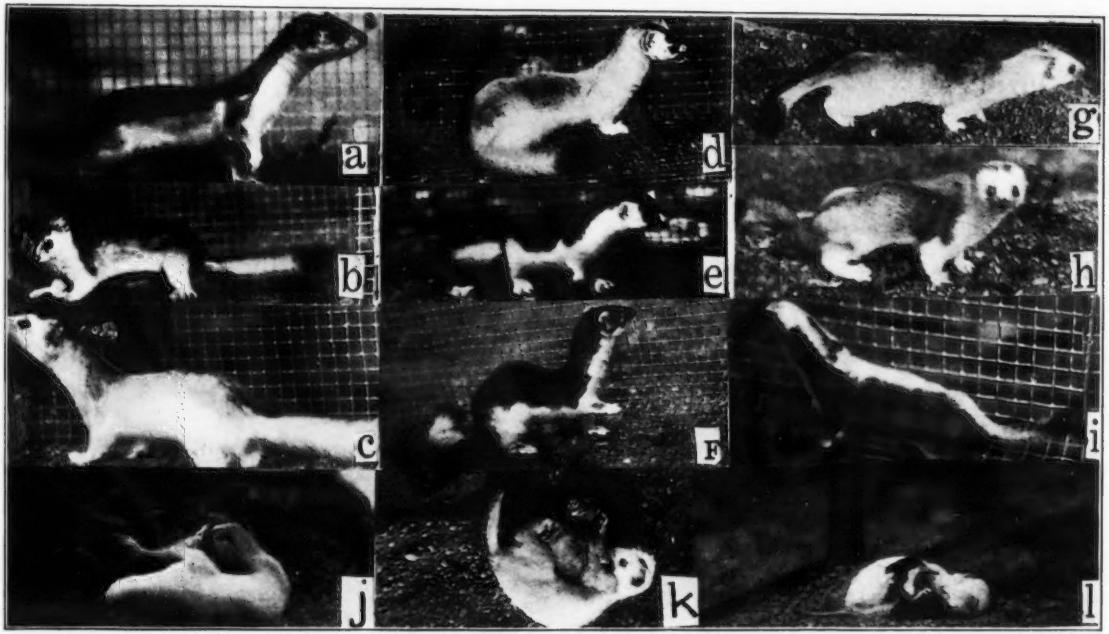
Fig. j. A female *Mustela cicognanii* killing a rat. Ithaca, N. Y., March 10, 1933.

Fig. k. Illustrating the manner in which a weasel holds a rat or mouse when killing it. A female *cicognanii* with a rat she has just killed. March 12, 1933.

Fig. l. A female *Mustela cicognanii* killing a deer mouse. March 20, 1932.

PLATE IX

PLATE IX



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TWO NEW RECORDS OF THE LEAST WEASEL IN INDIANA*

MARCUS WARD LYON, JR.

The first positive record of the Least Weasel, *Mustela rixosa allegheniensis* (Rhoads) in Indiana is that published by Dice[1] in February 1928. This record is based on a single specimen collected by the late E. B. Williamson on February 7, 1927 in Wells County. A dog caught it as it ran out from a corn shock, and Mr. Williamson was quick to recognize its value. The specimen is now in the collection of the Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

The earliest publication which may refer to the Least Weasel in Indiana is that of Plummer[2] in a list of Mammals of Wayne County in 1844. He mentions as occurring in the County *Putorius pusillus*. No other species of weasel is mentioned but as the list is not based on museum specimens and measurements and description of the weasel are not given, it can not be definitely established that Plummer was referring to the Least Weasel or to the more common New York Weasel or possibly to Bonaparte's Weasel. One would infer, however, from the specific name *pusillus* that he was dealing with a small species of weasel and not with the larger and more common New York Weasel.

The most definite early reference to the Least Weasel in

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* Read at the 15th Annual Meeting of the American Society of Mammalogists, Cambridge, Mass., May 10-12, 1933.

1 *Dice, L. R.* The Least Weasel in Indiana, Journ. Mammalogy, Vol. 9, p. 63, Feb. 1928.

2 *Plummer, John T.* Quadrupeds about Richmond, Wayne County, Indiana, Amer. Journ. Sci. Arts, Vol 46, p. 244, 1844.

Fig. 1. Mounted specimen of Allegheny Least Weasel, *Mustela rixosa allegheniensis* (Rhoads), natural size, owned by Mr. Elmer Baumgartner, Bluffton, Indiana, and caught by him in a gravel pit at Bluffton.

Indiana is that of Kennicott[3] in 1859. He says the Least Weasel is found in northern Indiana and Illinois. Kennicott[4], [5] was familiar with the New York Weasel, and includes it in his lists of Illinois mammals. In view of Williamson's recent discovery of the Least Weasel in northern Indiana and the existence of two more specimens here recorded there is no doubt that Kennicott was correct in his statement that the Least Weasel, called by him *Putorius pusillus*, occurs in northern Indiana.

Hahn[6] knew of no specimens of the Least Weasel but sur-

Fig. 2. Palatal, lateral and dorsal views of skull of Alleghenian Least Weasel, *Mustela rixosa allegheniensis* (Rhoads), about natural size, owned by Mr. H. P. Cottingham, Medaryville, Pulaski County, Indiana. Caught by him at the same place, when turned out of hole by a plow; autumn of 1932, adult female, body preserved in alcohol.

Fig. 1. Mounted specimen of Alleghenian Least Weasel, *Mustela rixosa allegheniensis* (Rhoads), natural size, owned by Mr. Elmer Baumgartner, Bluffton, Indiana, and caught by him in a gravel pit at Bluffton.

[3] *Kennicott, Robert.* The Quadrupeds of Illinois injurious and beneficial to the farmer. U. S. Pat. Off. Rep. Agri. for 1858, p. 245, 1859.

[4] *Kennicott, Robert.* Catalogue of animals observed in Cook County, Illinois. Trans. Illinois State Agri. Soc., Vol. 1, 1853-54, p. 578, 1855.

[5] *Kennicott, Robert.* The Quadrupeds of Illinois injurious and beneficial to the farmer. U. S. Pat. Off. Rep. Agri. for 1857, p. 104, 1858.

[6] *Hahn, Walter Louis.* The Mammals of Indiana. 33rd Ann. Rep. Dept. Geol. Nat. Res. Indiana, for 1908, p. 646, 1909.

mised on purely zoogeographic grounds that its presence might be expected anywhere in Indiana, especially the northern part. Curiosly enough he makes no mention of Plummer's or Kennicott's observations.

Henninger[7], in 1923 wrote "Real, earnest and persistent effort by Indiana mammalogists will no doubt prove it *(Mustela allegheniensis)* to occur there." Henninger's contention that the Least Weasel would be found in Indiana was proven about five years later by an entomologist, E. B. Williamson.

Mr. Chas. C. Deam, about two years ago wrote me that Mr. Elmer Baumgartner, of Bluffton, Wells County, Indiana had a mounted weasel which appeared to belong to the same species as that captured by his fellow townsman, E. B. Williamson, a few years previously. Mr. Baumgartner kindly lent me that specimen for examination, and making a photograph, which is here reproduced actual size as figure 1. The specimen was caught in a gravel pit at Bluffton.

Early this year Mr. Sidney Esten wrote me that Mr. H. P. Cottingham of Medaryville, Pulaski County, had preserved in alcohol what appeared to be a specimen of the Least Weasel. Mr. Cottingham kindly lent me the specimen for examination. I removed its skull and natural size photographs of it are here reproduced as figure 2. This specimen was turned out from a shallow hole by a plow in the autumn of 1932. It is a female, evidently nursing as judged by the condition of the mammae, which are 6 in number, 1-1 inguinal and 2-2 posterior abdominal.

The Least Weasel is probably as common in northern Indiana as it is in other parts of its range. In the past it has been singularly elusive, but in recent years specimens have become increasingly more numerous. See publications of

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7 *Henninger, W. P.* On the status of Mustela allegheniensis, Journ. Mammalogy, Vol. 4, p. 121, May 1923.

Swenk,[8] Gregory and Sanborn,[9] and Sutton.[10] As many as possible of the skulls of all weasels taken for fur ought to be critically examined by someone interested in mammals not only for securing additional specimens of this species but also for possibly finding Bonaparte's Weasel which has not yet been reported for Indiana, but may occur in the state as it has been taken as close to Indiana as New Bremen, Ohio.[11]

SOUTH BEND, INDIANA

8 *Swenk, Myron H.* Notes on Mustela campestris Jackson, and on the American forms of Least Weasels, Journ. Mammalogy, Vol. 7, pp. 313-330, November 1926.

9 *Gregory, Tappan* and *Colin Campbell Sanborn.* The Least Weasel, Mustela allegheniensis, in Illinois, Journ. Mammalogy, Vol. 10, p. 251, August 1929.

10 *Sutton, George Miksch.* The Alleghenian Least Weasel in Pennsylvania. Journ. Mammalogy, Vol. 10, pp. 252-254, August 1929.

11 *Henninger, W. P.* Two Mammals new for Ohio. Journ. Mammalogy, Vol. 2, p. 239, November 1921.

AMPHIBIANS FROM THE GREAT BASIN OF THE WEST AND ADJACENT AREAS (1932)

CHARLES E. BURT

The collection of amphibians on which the present contribution is based was assembled in the western half of the United States during August, 1932. In addition to records and ecological annotations secured by myself, reports are included from specimens kindly given to me during the past year by Lewis T. Barry and Ottys Sanders.

LIST OF SPECIES

SALAMANDERS

Ambystoma triginum (Green)

A large tiger salamander was collected by Lewis T. Barry at Denver, Denver County, Colorado, on August 30, 1932. It has light spots high on the back and the amount of dark pigmentation on the body is proportionately lessened. There is distinct contrast between the darker and lighter parts of the color pattern.

A second example, with a body length of 96 millimeters and a tail measuring 86 (total 182), was secured one mile north of Las Vegas, San Miguel County, New Mexico, on the cloudy day of August 27, at a spot where it had wandered out upon a cement pavement from grass above ponds near the Conchos River.

TOADS

Scaphiopus hammondii Baird

In Arizona, on the outskirts of Seligman, Yavapai County, the metamorphosing young of this spadefoot toad were serured on August 24. The tail was present on all but the stouter, larger examples and the body measured from 13 to 16 millimeters in length in the toads in the series. The backs of all individuals were uniform blue-gray, and the underparts were white. The habitat was a shallow, moderate-sized

open pond with no vegetation at the edge. The water was muddy and the pool appeared to be more or less temporary in nature. The young toads were imbedded under rocks at the edge of the water, where capillary action through the sandy soil provided a constant source of moisture.

California: Orange County, on the basis of a specimen taken by R. H. Kimball in February 1896 (Mus. Kan. St. Coll No. 49).

Colorado: 2 miles east of Strasburg, Arapahoe County; and University Park in Denver, Denver County (from Lewis T. Barry). The Strasburg specimen was hopping on sandy soil early on the sunny morning of August 6.

Bufo cangicus cangicus (Pallas)

In Colorado, this toad was very abundant in the vicinity of a small pond formed as an extension of Cold Stream, a short distance north of Barren Lake, Grand Mesa Resort on Grand Mesa, in Delta County. Both young and adults were numerous in the grass at the edge of this pond at noon on August 9. Some individuals were under rocks, logs, and boards, and one adult was found floating among reeds in the open water near the middle of the pond. When handled these toads give off an odor which reminds one of the smell of the Jimson weed, which often grows in barnyards in Kansas.

Additional Colorado specimens of *Bufo cangicus cangicus* were found under logs above a spring on the bank of Egleston Lake, Grand Mesa Resort, on Grand Mesa, Delta County; and at the Rocky Mountain Biological Laboratory near Gothic, Gunnison County. The last report is from a specimen collected by Ottys Sanders.

In Utah, specimens were secured 1 mile west of Colton, and 3 miles west of Colton, in Utah County, on the banks of a small grass-bordered stream.

This subspecies may be distinguished from *Bufo woodhousii* of the same general region both by its characteristic smell and by the presence of dark markings on the ventral surface.

Bufo cognatus (Say)

In California, one of these toads was collected under a street light at Needles, San Bernardino County, during the torrid night of August 23; and in Colorado, another was taken from the road above a pond 10 miles east of Anton, Washington County, on the evening of August 5.

Bufo woodhousii Girard

Records of the occurrence of this fine toad were obtained as follows:

Colorado: at the edge of an irrigation ditch 4 miles southwest of Delta, Delta County; at Concrete, Fremont County; and on the wet sand at the edge of Roubideau Creek 13 miles southwest of Delta, in Montrose County. The latter examples, which were young with body lengths varying from 15 to 18 millimeters, were collected on August 10.

New Mexico: on the pavement of a mountain road 4 miles west of Pecos, Sante Fe County, on the night of August 26.

Utah: at the grassy edge of a large pond 2 miles northeast of Delta, Millard County, on August 11.

FROGS

Pseudacris triseriata triseriata (Wied)

Reasons for placing this form in subspecific relationship with the Texan *clarkii* are incorporated in my forthcoming study entitled "A Contribution to the Knowledge of the Amphibians and Reptiles of Texas."

Colorado specimens are somewhat intermediate between my conception of the two forms, but with the dark markings on the back showing a greater or lesser amount of the confluent longitudinal arrangement characteristic of *triseriata*, rather than the loss of this feature as it appears in typical *clarkii*. Some breaking of the longitudinal dark lines appears in certain Colorado examples taken during the daytime on August 9 in the grass at the side of a pond formed as an extension of Cold Stream just north of Barren Lake at the Grand Mesa Resort on Grand Mesa, Delta County, where a few notes of the song were heard now and then. The same tendency toward spotting is seen in other examples, which

were secured on August 5 as they were singing at night from temporary rain ponds 11 miles east of Anton, Washington County, where they were clinging to the upright stems of submerged weeds and grasses.

Rana boylii boylii (Baird)

These diminutive frogs were secured near streams 6 miles west of Carl Inn, and 2 miles northwest of Jacksonville, in Tuolumne County, California.

Rana catesbeiana Shaw

The introduction of the eastern bullfrog into California was discussed by Storer (1922), and additional records have come to light since that time. Judging from the present observations, bullfrogs must now be recognized as well established in the far West, for in the two localities to be reported below they occurred in such abundance as to be the dominant vertebrate life of the pools that they were inhabiting. Specimens from both places have been kindly identified by Dr. Storer.

The first report is from a small, clear stream with a gravel bottom and a grassy edge on the outskirts of Roseville, Placer County, where mats of algae and water plants afforded concealment, and therefore protection, to the tadpoles and the young. Metamorphosing types, tailed to tailless, were numerous here on August 14.

The second report is from a stream about 2 miles northwest of Jacksonville, Tuolumne County, where shallow, still water was in evidence at dusk on August 16. The species was so numerous in this place that almost 100 specimens, mostly newly metamorphosed, tailless young, were secured in less than two hours. When frightened, some frogs skipped for 20 feet or so across the water without sinking by means of rapid, dexterous paddlings of the hind feet; others dived for long distances under water, finally coming out on the opposite bank or seeking concealment either in algae mats in the water or in the mud and gravel at the bottom of the stream.

Rana pipiens Schreber

Leopard frogs were secured in many places about permanent flows or bodies of water as follows:

Colorado: at an irrigation ditch 4 miles southwest of Delta, Delta County; about a small algae bordered pond with some trees on its banks 4 miles west of Gunnison, and at the Rocky Mountain Biological Laboratory near Gothic (report from Ottys Sanders), in Gunnison County; about a pond and an irrigation ditch 6 miles southeast of Whitewater, Mesa County; and at the edge of the sandy bottomed Roubideau Creek 12 miles southwest of Delta, in Montrose County.

Nevada: in a pond with cattails and an algal scum 8 miles east of Fallon, Churchill County; and about a small pond with algae (at the base of mountains) 1 mile southeast of Fernley, Lyon County.

New Mexico: near an algal pond with grassy banks (on which some willows were growing) in the valley of the Rio Grande 1 mile southeast of Isleta, Bernalillo County; on the grassy banks of the Sapello River at Watrous, Mora County; on the grassy banks of the Conchos River 1 mile north of Las Vegas, San Miguel County; at the grassy edge of the Ute Creek 3 miles northeast of Gladstone, Union County; and about an irrigation ditch leading from the Rio Grande at Los Lunos, Valencia County. In the last locality and various others the water was partially filled with aquatic vegetation. In such cases frogs were readily secured by grabbing algal mats in front of the points where they were seen to diappear.

Utah: Near a cattail filled roadside ditch at Greenriver, Emery County; at the grassy edge of a pond 2 miles northeast of Delta, Millard County; and at a small pool 3 miles west of Colton (including tadpoles and metamorphosing young), and in the grass and shallow water near Strawberry Reservoir 3 miles northwest of Thistle, in Utah County.

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THE NORTH AMERICAN JURASSIC UNCONFORMITIES.

C. H. CRICKMAY

I. PURPOSE OF THIS ARTICLE.

The Jurassic System in North America varies greatly from place to place in composition, structure, and thickness. Compared with the Jurassic of Europe, it is, in spite of great thickness in a few localities, a very incomplete record. The nature of this incompleteness is of unusual interest, and has not been well understood. Part of it is connected with recognizable unconformities occurring mostly round the edges of the central belt of the Cordillera, which was a land mass in Jurassic time. It is with these unconformities that this article deals.

II. DESCRIPTION OF UNCONFORMITIES.

The contact between Triassic and Jurassic rocks involves, in some places, a profound discordance; yet nowhere is it marked by a very great hiatus. In western Nevada, the hiatus is very small: it involves Rhaetic and basal Lias up to the zone of *Schlotheimia*,[1] comprising about eight per cent. of Triassic time plus one per cent. of Jurassic. If we may regard the Mesozoic periods as roughly equal, this result may be summed up as nine per cent of a geologic period.[2] The contact at this place, however, has not yet been shown to be more than disconformable.

The rocks above this contact in Nevada are unfossiliferous "breccias," that is, ill-sorted clastic deposits with angular

[1] S. Muller, Oral communications to Geological Society of America, Cordilleran Section meetings, 1928 and 1929.

[2] The fractional values assigned to certain parts of the Mesozoic periods are based on paleontological chronology, especially the work of S. S. Buckman, though supplemented, of course, by that of others. These values are independent of sedimentary thickness which is no basis for chronology. The fractions have been given a uniform denominator of 100 for convenience of expression as percentages.

fragments.[3] These characteristics point to a fluvial origin. If this reasoning is trustworthy, it may be safe to argue that since fluvial deposits were the first to be formed on the planed surface which is now seen in the contact, the agent of planation was running water. On the other hand, certain other localities exhibiting the same unconformity in northern California do not in any way suggest such an origin. Localities on the British Columbia coast, though they show unfossiliferous clastics above the contact, do not particularly suggest fluvial action in the making of the unconformity.

Some of these other places yield evidence on the time involved. In northern California, at Mt. Jura, the hiatus between fossiliferous sedimentary rocks is from Rhaetic to early middle Lias, that is about eight per cent. of the Triassic plus eight per cent. of the Jurassic, or sixteen per cent. of a period. The erosion concerned in making the unconformity may well have been accomplished in still less time. However, the contact is a very marked unconformity: the basal Jurassic lies in places on Noric equivalents, in others on Lower Triassic volcanics.[4]

On the British Columbia coast, the hiatus is very small, but the discordance is scarcely perceptible.[5] Sufficient localities are not yet known in that region for a measurement of the amount of erosion. Rhaetic and basal Lias only are missing, hence the time value of the gap in the record is about the same as in western Nevada—nine per cent. of a period. It would be highly desirable to have the important Queen Charlotte Island localities, long ago studied by Dawson, reexamined; and to have a search made for localities in the Coast Range Mountains of British Columbia. If records of early Jurassic by Daly,[6] and by Cairnes [7] are correct, the northern Cascade Mountains ought to provide, with sufficient study, some interesting evidence.

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[3] *H. W. Turner*, American Geol., vol. 29, p. 261. 1902.

[4] The author's field-work of 1928-1932.

[5] *C. H. Crickmay*, Univ. California Publ., Geol., vol. 18, No. 2, 1928.

[6] *R. A. Daly*, Memoir 38, p. 517, Geol. Survey Canada, 1913 mentioning *Arniotites*.

[7] *C. E. Cairnes*, Memoir 139, p. 65, Geol. Survey Canada, 1924; mentioning *Arniotites*.

A very strong discordance is found in central Oregon,[8] where the hiatus is only slightly ggreater—about twenty-five per cent. of a period. This region is ill-known as yet, but it is hoped that Mr. Lupher's researches will make its Mesozoic history clearer.

These various, and widely scattered, contacts record the events which closed the Triassic and initiated the Jurassic. To sum up these events, historically: The Triassic epicontinental sea withdrew about the end of Juvavic time, the broad coastal belt of the late Triassic "North America" was deformed, especially along its inner margin, and elevation became general. Then parts of the elevations were planed by erosion, and a new sea advanced and formed its deposits, even across the bevelled roots of the mountains. Let it be emphasized that all these events occurred within one-fourth of a geologic period, and at many places in much shorter time. Obviously, the erosional levelling which entered into the making of the unconformities transpired in considerably less time.

One important, yet uncertain element enters into these reconstructions: the actual quantity of material removed by erosion. The estimation of this is apt to be very rough in a sphere as little known as the west American Jurassic. In many places, the structures suggest that two or three thousand feet in the vertical dimension has been removed. In others, where no discordance occurs, the quantity is undoubtedly much less, perhaps not more than two or three hundred feet.

Higher in the Jurassic System there are other significant unconformitties. One which seems to have a very small time value has been reported from the Middle Jurassic of central Oregon.[9] However, it has not been described in print, and is therefore undesirable to use as an example.

Some important unconformities are known in the Upper Jurassic rocks. The early Upper Jurassic formations, all along the Pacific border, are sharply distinct from the Middle Upper Jurassic. The former are mostly of very fine grain,

[8] R. L. Lupher's collections, and personal communications.

[9] R. L. Lupher, oral communication to Geological Society of America, Cordilleran Section meeting 1930.

the latter are coarse. This contrast, in itself, being widely developed, suggests some sort of an upheaval, and possibly an erosional gap in the record.[10] An estimation of the value of this gap may be made at Harrison Lake, in southwestern British Columbia. At this locality, the Kent formation—a coarse, unfossiliferous conglomerate, 3,000 feet thick—forming the base of the Middle Upper Jurassic (Argovian or *"Cardioceras")* deposits, lies with notable discordance on the earlier Upper Jurassic Mysterious Creek formation (Callovian or *Cadoceras)*. The hiatus covers, therefore, only the Divesian age, or about six per cent. of Jurassic time. Yet, during this brief interval the Agassiz Mountains were built and destroyed: a great piece of denudation was prepared for, consummated, and its records buried beneath the sea.[10]

This unconformity seems to pass into a mere disconformity in other places; but nevertheless, the break in the record, of whatever sort, is of wide occurrence. It appears, though obscurely, at Mt. Jura, California.[11] It may be seen in the Rocky Mountain Jurassic,[12] from the Gallatin Mountains northward into Canada, in the break between the equivalents of the Ellis and equivalents of the Sundance formation. It shows up plainly in the Jurassic of southern Alaska, in the Chinitna-Naknek disconformity.

The rocks directly above this unconformable contact are, at most places, coarse, unfossiliferous, arkosic clastics, commonly of great thickness. Like the Nevada example of the basal unconformity, they seem to indicate an origin of the discordance through fluvial planation.

A somewhat later unconformity was found at Mt. Jura, California, in the course of my study of that classic locality, 1928-32. This one divides Kimmeridgian deposits below from Tithonian above. The hiatus, therefore, seems to cover the Portlandian age, or five per cent. of the Jurassic period. The discordance is quite marked, amounting to twenty degrees and the erosion was great, for it removed thick formations of sedimentary rock, and denuded certain notable hypabyssal

[10] *C. H. Crickmay*, Proc. Am. Phil. Soc., vol. 70, 1931.
[11] C. H. Crickmay, field-work, 1928-1932.
[12] C. H. Crickmay, field-work, 1930, 1932.

igneous masses—the Diller quartz porphyry. Unfortunately, equivalents of this unconformity are difficult to find. Possibly corresponding to it is a late Upper Jurassic unconformity in southern Alaska, supposedly within the Naknek [13] series, and hitherto regarded as unimportant and local. This contact is a striking one, though the discordance is almost nothing, and the hiatus seemingly very short. Stanton concluded that the fossils above the break were the same as those below, though the collections were very small. It would be desirable to have confirmation of the supposed faunal difference, as well as an exact correlation of the age of the break.

One of the most remarkable of all the unconformities is that which separates the Jurassic System from the Cretaceous. This was formerly thought to be profoundly discordant. It is now known to be nearly accordant, or only slightly discordant, in most places, and notably discordant in very few. Whatever its character, the unconformity has wide extent, being known in the Coast Ranges of the Pacific States, in British Columbia, Yukon, and Alaska. At most places, the youngest rocks below the unconformity are mid Upper Jurassic, or Kimmeridgian. The oldest rocks above it are early Neocomian (Subcraspeditan, *piochii*). This hiatus involves, therefore, Portlandian and Tithonian—ten per cent. Jurassic of time, plus the earliest part of the Neocomian—three per cent. of the Cretaceous; that is thirteen per cent. of a geologic period.[14]

Even this seems a remarkably short time when consideration is taken of the wide extent and marked character of the discordance. However, near Nipomo, San Luis Obispo County, California, this Jurasso-Cretaceous unconformity is narrowly limited between Tithonian beds (Berriasellidan, *calisto)* and early Neocomian (Subcraspeditan, *piochii).*[15] This means that the hiatus involves only about one per cent. of Juraassic time, plus three per cent. of Cretaceous; that is, four per cent. of a period. Probably, a similar value for the supra-Jurassic hiatus would be obtained in northern Cali-

[13] *T. W. Stanton* and *G. C. Martin,* Geol. Soc. America, Bull., vol. 16, p. 407, Pl. 70.

[14] *C. H. Crickmay,* Proc. Am. Phil, Soc., vol. 70, 1931.

[15] *C. H. Crickmay,* This Journal, vol. 13, No. 1, 1932.

fornia, if the relations between the Jurassic Knoxville shale and the Cretaceous Knoxville sandstone were worked out.

The rocks directly above this supra-Jurassic unconformity are, nearly everywhere, conglomerates containing a few fossils of marine origin, and well rounded pebbles and cobbles of a great many different rock types. The agent which planed the surface entering into this unconformity may well have been sea waves.

This descriptive account has been made brief purposely. None of the unconformities are so innaccessible either in the field or in the literature as to warrant repeating any but the most essential information.

III. SOME FURTHER CONSIDERATIONS.

At this point let it be repeated and emphasized that the short periods marked by these unconformities were filled with various happenings among which denudation was only one. Hence, the denudation occupied mere fractions of the periods quoted. Yet each unconformity records notable erosion, comparable to what is commonly called a "local cycle of erosion." Indeed, the flatness of the contacts seems to show that flat erosional plains were produced.

Most of the uncomfortable contacts are remarkable in being overlain by a notable thickness of coarse sediment. It seems surprising that a flat, approximately base-levelled surface which plainly marks the end-stage of at least a "local cycle of erosion" should be overlain by a coarse detrital deposit such as might be derived only from a region of some elevation and relief. The relations make it appear that while one area was being cut to low level and flatness, a neighboring area was spared by erosion so that it maintained its ability to produce coarse detritus.

The materials of this detritus, now preserved in the basal deposits of the several Jurassic and Cretaceous series, show that the principal area which maintained its elevation was the Intermontane Geanticline. This includes what is now eastern Nevada, central Idaho, and the Gold Ranges of British Columbia—the region from which Jurassic rocks are utterly lacking. This area has been an element in the continental structure since very ancient times. In the Jurassic, it appears

as the prominent, persistently elevated lands which I have called Jurosonora and Jurozephyria. A similar land lay in what is now central Alaska, and this I have called Juroberingia.

The close juxtaposition of the Jurassic formations to the geanticline suggests that the deposits were formed on plains abutting against highlands. Such a relationship makes it seem likely that the plains were formed by an agent which acted horizontally, carving a low flat surface by paring away the margins of the highlands, and working rapidly so as to complete the task before other erosional agents has reduced the highlands. It will be recalled that paleontological evidence has already shown independently that the planation was rapidly completed.

It seems probable that the horizontal planation resulted from the concentration of a corrasive agent on a certain area. Simple wasting had no great part, for wasting is universal. Furthermore, the erosion was far more rapid than the progress of wasting could have been under the most favorable circumstances. To corrasive agents seem to have contributed to the planation: some of the unconformities owe their making to the action of sea waves; others were formed by horizontal, or lateral, cutting and filling by rivers.

The attempt to reconstruct the physical conditions and processes under which the unconformities originated may well rest with these results. The problem of the length of time marked by the hiati remains to be examined. Recent estimates accredited 200,000,000 years to Mesozoic and Cenozoic, divided as follows:[16]

Cenozoic	50,000,000 years
Cretaceous	70,000,000 years
Jurassic	40,000,000 years
Triassic	40,000,000 years

These are rather conservative with regard to Triassic and Jurassic; and, on the basis of evolutionary advance among mollusks, brachiopods, and a great many other important groups, it seems better to regard the Mesozoic periods as roughly equal, and of about 55,000,000 years duration each. If this be accepted, then the Jurassic hiati of nine, six, five,

[16] Bulletin 80, National Research Council. Washington, D. C., 1931.

and four per cent. of a Mesozoic period correspond to geologically brief epochs of 4,950,000, 3,300,000, 2,750,000, and 2,200,000 years. Perhaps, the planation of the unconformity surfaces was accomplished in half these periods, that is, from one to two-and-a-half million years. These figures are widely different from the thirty to fifty million years which we commonly, though perhaps quite wrongly, attribute to the "cycle of erosion."[17] However, the unconformities do not prove that "erosion cycles" were completed in a million years or so, but rather, that in limited areas erosional planation was completed in such brief periods. In other words, certain "local cycles of erosion" were brought to completion in small fractions, (one-twentieth to one-thirtieth), of the time they would be expected to require. This seems at first very puzzling, and may not be explained, as some of my friends have suggested, on any assumptions that erosive agents were more powerful during the Jurassic, or that the rocks on which they acted were unconsolidated or weak. There are no more grounds for such explanations than there are for concluding that we are grossly in error in our estimates of the length of geologic time. Indeed, what is needed is understanding, not explanations. The testimony of the Jurassic rocks leads inevitably to the conclusion that a small area may be base-levelled in a short time. Possibly, the time required for the base-levelling is proportional in some way to the area eroded; for, just as the Jurassic unconformities cover about five per cent. o fthe area of North America, so the erosional epochs they represent cover about five per cent. of the time which it is calculated would be necessary for the base-levelling of the continent.

It remains for physical geology to find the analogy among present day processes of these seemingly inconsistent happenings of Jurassic time, unless we are to conclude that there is too little exactitude in the doctrine of uniformitarianism for it to be applicable to the problems of historical geology.

[17] On the basis of 15,000,000 to reduce North America to base-level at the existing rate of denudation in the Mississippi basin (Dole and Stabler, U. S. G. S. Water Supply Paper 234, pp. 78-93, 1909), tempered by Barrell's factor for the supposed slowing down of the rate in geographical old age (Barrell, Geol. Soc. America, Bull., vol. 28, pp. 745-904, 1917).

A PHYLLOCARID CRUSTACEAN FROM THE DEVONIAN ROCKS OF OHIO.

GRACE ANNE STEWART

I. INTRODUCTION

Fragments of a phyllocarid crustacean have been observed in earlier collections of fossils from the Silica shale, and during the past year a specimen has been found which is preserved sufficiently well for identification. Since it belongs to an undescribed species and appears to offer additional evidence for the Hamilton age of the Silica shale, concerning which some question has been raised, it seems worth while to record it.

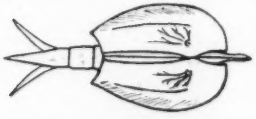


Fig. 1 Diagrammatic figure showing the carapace structure in *Rhinocaris* (after Clarke).

Our specimen belongs to the genus *Rhinocaris*, which was originally described by John M. Clarke[1] on the basis of a single crushed specimen. The specimen was compressed in such a manner as to destroy all evidence of a hinge and to make the rostrum appear to be continuous with the carapace. For these reasons the carapace was thought to be univalvular, and the form taxonomically to be intermediate between the Phyllocarida and the Decapoda.

In the course of several years, additional specimens of this interesting crustacean came to light, revealing important features hitherto unrecognized, which led Clarke to revise his original description of the genus.[2] He found that the carapace of *Rhinocaris columbina*, the type species, consisted of four parts instead of one: two broad lateral valves which extend

[1] *Clarke, John M.*, Pal. N. Y., vol. 7, p. 58, 1888.

[2] *Clarke, John M.*, Am. Nat., vol. 27, p. 793, 1893.

downward over the sides of the cephalothorax and are in contact only at a single point in the dorsal line about one-fourth the distance from the anterior margin; a narrow lanceolate median plate lying between the two valves posterior to their point of contact; and an anterior dorsal plate called the rostrum which projects beyond the frontal margin of the valves. The union of the valves with the median and rostrum plates thus comprises a double hinge structure. Since the plates are readily separable along the sutures between the plates, the complete carapace is rarely found.

The Silica shale specimen shows only the right valve, which is not entirely complete. It is partly crushed and a portion of the posterior end is broken. But the general shape and the surface sculpture are sufficient to demonstrate without doubt its position in the genus *Rhinocaris*, and its distinctness from any described species. A discussion of the specimen follows.

II. DESCRIPTION OF SPECIES

Rhinocaris ehlersi Stewart, n. sp.

Plate X, Figs. 1-3.

D e s c r i p t i o n . — Right valve of carapace known only in part. The shape is elongate semi-oval, wider anteriorly, the length being about twice the width. The dimensions are: length, 61 millimeters; greatest width, 30 millimeters.

Dorsal margin approximately straight with a slight obtuse projection about one-fourth the distance from the anterior end. This projection is presumably the point of contact of the valves. The eye node, which in the genus *Rhinocaris* is situated opposite this point of contact about one-fourth the distance below the dorsal line of each valve, is not visible in our specimen. The obscurity of this feature is doubtless occasioned by the crushing which the test has undergone in this region. Likewise the crushing has obliterated all traces of the eye sinuses. A small swelling is present in the anterior angle of the shell just below the dorsal margin. This swelling may represent the eye node, but it is highly improbable because of its position so far front.

The surface of the valve is convex, becoming less so ventrally. The edge of the shell, except dorsally, is bounded by a narrow flat band. The anterior margin of the valve curves evenly into the gently convex ventral margin, which is terminated posteriorly in a short broad spine. Above the spine the posterior margin is concave and evidently incurves slightly below the dorsal angle.

Fine, distinctly etched, closely spaced lines are present on the ventral one-third of the valve, where they approximately parallel the edge. The lines converge anteriorly and posteriorly and curve upward toward the dorsal angles. The portion of the valve which is free from these lines is marked by numerous small, irregularly shaped pits of variable size. A few of these pits can be observed even within the line-covered part of the valve. Minute tubercles marking the bases of spines are distributed sparsely over the surface.

Remarks.—This species differs in certain essentials from the described forms. It resembles most closely *Rhinocaris columbina* var *livonensis*; but the shape is somewhat different, no trace of the characteristic carinae of that species has been seen, and in addition, occasional spines are scattered over the surface. From *Rhinocaris columbina* it differs in these same respects and is much larger.

When the fauna of the Silica shale was originally described,[3] the writer recognized a large percentage of Hamilton forms and, on the basis of these, determined the Silica shale as Hamilton in age. As additional species come to light it is significant that this Hamilton trait is again emphasized. The closest counterpart of the form under discussion, for example, is the above-mentioned *Rhinocaris columbina* var. *livonensis,* which has been found, so far as the writer knows, only in the Hamilton shale of New York State. The balance of evidence appears to be still in favor of Hamilton age for the Silica shale rather than for Upper Devonian, as has been suggested.

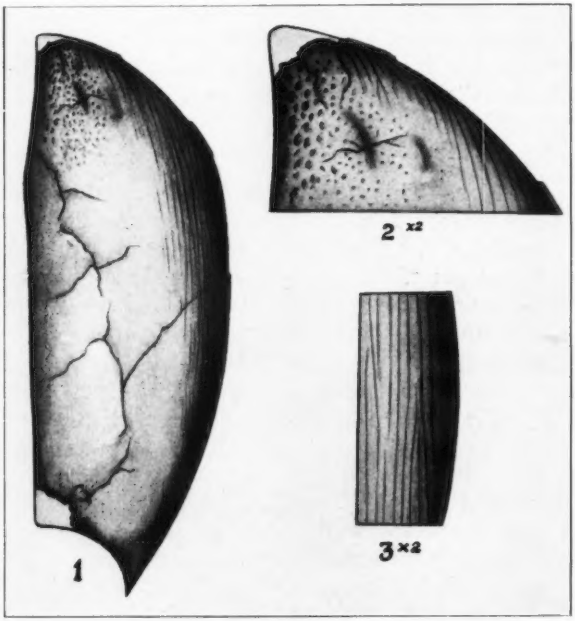
An added interesting feature of our specimen is the retention of the original color on certain portions of the test. This

[3] *Stewart, Grace A.*, Geol. Surv. of Ohio, Fourth series, Bull. 32, 1927.

shows up as an iridescent luster with brown and purple hues predominating. Few fossils with the original color preserved have been reported from the Devonian rocks of Ohio.

The species is named for Professor G. M. Ehlers, who found the specimen and made it available to the writer for study and description. Holotype: Catalogue No. 17802, Geological Museum, Ohio State University.

OHIO STATE UNIVERSITY,
COLUMBUS, OHIO.



Drawing by Dwight W. Curtiss.

PLATE X.

Figs.

1.–3. *Rhinocaris ehlersi* Stewart, n. sp.

1. View of right valve of carapace.
2. Enlargement of anterior end, showing the pitted surface and the converging lines. x 2.
3. Enlargement along the ventral margin, showing the arrangement of the lines. x 2.

A STUDY OF VEIN ENDINGS IN LEAVES*

ROY W. STRAIN

It is remarkable that although nearly every elementary textbook of Botany shows a drawing of a vascular bundle-end in a leaf, no detailed study of vein ends appears to have been made. Leaf venation in one aspect or another has been the subject of a host of investigations. Some of these, such as that of Haberlandt (4) have dealt with the details of leaf anatomy. More of them have treated the rate of development, orientation of bundles etc., rather than the detailed structure. Schuster (6) is an example of this group. Col (2), and Gerresheim (3) have made very extensive studies on the vascular bundles of leaves but have not given any details of vein endings.

The size of vein islets has been investigated by Benedict (1), Yapp (7), and Zalenski (8), but none of these has presented details of the minute subdivisions of the vascular bundles.

Rippel (5), it is true, has counted the number of tracheids in vascular bundles in leaves, but he has been interested in typical cross sections of bundles rather than in their terminations.

The present study was undertaken to fill the gap in our knowledge of this detail of leaf anatomy, and also to determine whether or not the vein ending might be used as a character in phylogenetic studies.

METHOD

In microtome sections of leaves one can determine the number of tracheids in a bundle with ease, but it is impossible to tell anything about their shape and length. It is impossible, also, to tell how near the end of a vein a given section may be located. It soon became apparent that for the purposes of the proposed study cross sections were of limited value. Pieces of leaves which had been thoroughly cleared so that they were

* Papers from the Department of Botany of the University of Michigan, No. 429.

transparent proved best for the purpose, because the whole course of a bundle could be followed out to its termination. The epidermal cells and the mesophyll was sufficiently transparent in well prepared leaves to allow drawings to be made of the vein endings, and this became the usual method of study of those structures. Drawings were made of from three to eight representative vein endings of each specimen studied. Those vein endings were selected which showed variations in size, form, and structure. Most of the drawings were made with a magnification of 440 diameters and by the aid of a camera lucida. In order that they could be studied accurately in every detail and compared, all, or practically all of the coloring matter had to be removed.

RESULTS

VEIN ENDINGS OF FOLIAGE LEAVES

Vein endings are composed largely of conductive elements which are reduced in size and number and consist usually of spiral or reticulate tracheids. Therefore, the observations of this study were confined to the number, size, shape, and position of these spiral or reticulate tracheids only.

It was found that vein endings have little or no phylogenetic significance. However, they could be classified on a structural basis into five major groups.

The largest group of vein endings, or 40 percent of the 118 species studied were veins whose xylem elements consisted of two parallel tracheids (Plate XII, Figs. A, B, C, D). Many of the tracheids were relatively long with somewhat smooth or wavy margins (Plate XII, Figs. B, D) while others were fairly short (Plate XII, Fig. A).

Single tracheid endings were next in order of frequency (Plate XI, Figs. E, F, G, H). This group comprised 31 percent of the species studied. Some of the single tracheid endings were long and narrow with smooth margins and tapering ends, while others differed by having irregular, more or less blunt ends. Many of the margins were wavy. The vein endings of *Datura suaveolens* were unique in that their tips were enlarged bulbous structures. (Plate XI, Fig. E). Other species in the same family failed to conform to this type.

Multiple endings of three or more tracheids comprised 17

percent of the species investigated (Plate XI, Figs. I, J, K, L). Generally the tracheids were relatively long and parallel to one another, although variations occurred.

In a few instances, in fact in six percent of the species studied, the vein endings were multiple, composed of irregular, triangular tracheids (Plate XII, Figs. E, F.) The tracheids varied considerably in size and shape.

Five percent of the species studied had multiple veins ending in a single tracheid (Plate XI, Figs. A, B, C, D). For the most part, the veins were composed of two tracheids, terminating with a single tracheid which varied in shape and size.

The vein endings of the following species were studied in detail:

SINGLE ENDINGS (SINGLE TRACHEID)

Commelinaceae
Tradescantia fluminensis
Urticaceae
Morus rubra
Ranunculaceae
Ranunculus reptans
Paeonia sp.
Anemonella thalictroides
Rosaceae
Geum rivale
Fragaria vesca
Leguminosae
Robinia viscosa
Desmodium grandiflorum
Phaseolus sp.
Desmodium canadense
Lathyrus ochroleucus
Lathyrus odoratus
Amphicarpa pitcheri
Cucurbitaceae
Cucurbita sativus
Compositae
Antennaria neglecta
Eupatorium perfoliatum
Tragopogon porrifolius
Ambrosia sp.
Geraniaceae
Geranium sp.
Simarubaceae
Ailanthus glandulosa
Sapindaceae
Cardiospermum hirsutum
Rhamnaceae
Ceanothus ovatus
Malvaceae
Althaea rosea
Hibiscus rosa-sinensis
Malvaviscus arboreus
Oleaceae
Syringa vulgaris
Solanaceae
Datura suaveolens
Datura stramonium
Scrophulariaceae
Verbascum thapsus
Compositae
Calendula officinalis
Lactuca sp.
Aster macrophyllus
Helianthus annuus
Taraxacum officinale
Sonchus arvensis
Bellis sp.
Vernonia missurica

MULTIPLE VEINS ENDING IN A SINGLE TRACHEID

Rosaceae
Rubus villosus
Waldsteinia fragarioides
Leguminosae
Lathyrus sp.
Melilotus alba
Convolvulaceae
Ipomoea purpurea
Bignoniaceae
Catalpa speciosa

MULTIPLE ENDINGS (TWO TRACHEIDS)

Ranunculaceae
Ranunculus sp.
Anemone canadensis
Clematis virginiana
Ranunculus septentrionalis
Aquilegia canadensis
Cruciferae
Raphanus sativus
Brassica caulorapa
Brassica oleracea capitata
Rosaceae
Fragaria virginiana
Rubus allegheniensis
Prunus cuneata
Rosa sp.
Rosa blanda
Crataegus sp.
Prunus americana
Rosa rugosa × *palustris*
Sorbaria sorbifolia
Rubus parviflorus
Leguminosae
Medicago sativa
Robinia viscosa
Lathyrus maritimus
Melilotus officinalis
Apios tuberosa
Vicia angustifolia
Cercis canadensis
Melilotus alba
Medicago sp.
Gleditsia triacanthos
Trifolium pratense
Linaceae
Linum grandiflorum
Vitaceae
Parthenocissus quinquefolia
Umbelliferae
Pastinaca sp.
Asclepiadaceae
Asclepias sp.
Solanaceae
Solanum dulcamara
Lycopersicon esculentum
Scrophulariaceae
Antirrhinum majus
Bignoniaceae
Begonia sp.
Plantaginaceae
Plantago major
Caprifoliaceae
Sambucus canadensis
Compositae
Sericocarpus asteroides
Helianthus divaricatus
Arctium minus
Agoseris glauca
Xanthium commune
Dahlia sp.
Bidens cernua
Senecio cruentis

MULTIPLE ENDINGS (THEE OR MORE TRACHEIDS)

Ranunculaceae
Hepatica triloba

Rosaceae
Rosa sp.
Pyrus communis

Leguminosae
Vicia cracca

Polygalaceae
Polygala paucifolia

Celastraceae
Celastrus scandens

Araliaceae
Hedera Helix

Compositae
Galinsoga parviflora
Liatris cylindracea
Aster lateriflorus
Artemisia absinthium
Senecio aureus
Aster laevis
Solidago altissima
Senecio sp.
Aster cordifolius
Hieracium venosum
Cirsium arvense
Senecio plattensis
Chrysanthemum sp.

MULTIPLE ENDINGS (IRREGULAR, TRIANGULAR TRACHEIDS)

Chenopodiaceae
Beta vulgaris

Leguminosae
Lupinus perennis
Astragalus neglectus

Rosaceae
Spiraea sp.

Umbelliferae
Daucus sp.

Compositae
Solidago sp.
Vernonia sp.

VEIN ENDINGS OF PETAL AND LEAF OF SAME PLANT

The vein endings of leaves and petals of the following plants were studied, *Melilotus alba, Anemonella thalictroides, Aquilegia canadensis, Lupinus perennis, Apios tuberosa, Gleditsia triacanthos, Anemone canadensis, Clematis virginiana, Ranunculus septentrionalis, Ranunculus reptans* and *Linum grandiflorum.* In the main, the vein endings of petals were single tracheids, regardless of whether those from leaves of the same plants were single tracheids or multiple tracheids.

VEIN ENDINGS OF COTYLEDONS

A study of the following plants showed very little or no difference in structure between vein endings of seed leaves and those of true leaves, both from the same plant: *Beta vulgaris, Helianthus annuus, Raphanus sativus, Brassica caulorapa, Brassica oleracea capitata, Lycopersicon esculentum com-*

mune, Cannabis sativa, Beta vulgaris cicla, Spinacia oleracea inermis, and *Impatiens balsamina.*

VEIN ENDINGS OF SUN AND SHADE LEAVES

Leaves were gathered from plants in the greenhouses of the University of Michigan Botanical Gardens. Two leaves were taken from the plant, one that was exposed to the sun as much as possible and one that was in the shade as much as possible. These specimens were cleared and the vein endings studied. Little or no difference could be distinguished between the vein endings of the two types of leaves. The following species were studied: *Malvaviscus arboreus, Tradescantia fluminensis, Lathyrus odoratus, Geranium* sp., *Hibiscus rosasinensis, Cardiospermum hirsutum, Senecio cruentus, Antirrhinum majus, Calendula officinalis, Citrus* sp., *Sterculia acerifolia,* and *Mahonia nepaulensis.*

SUMMARY

1. Vein endings were studied in 118 species of plants.

2. On a structural basis the vein terminations can be classified in five major groups. These groups appear to have no relation to the taxonomic position of the species studied.

3. The vein endings of the foliage leaves and of the cotyledons of a given species are practically alike structurally.

4. The vein endings of sun leaves and shade leaves do not differ within the species, either in arrangement or shape.

5. Vein terminals in petals are usually of the single tracheid type, regardless of the type to which the foliage leaves of the species belong.

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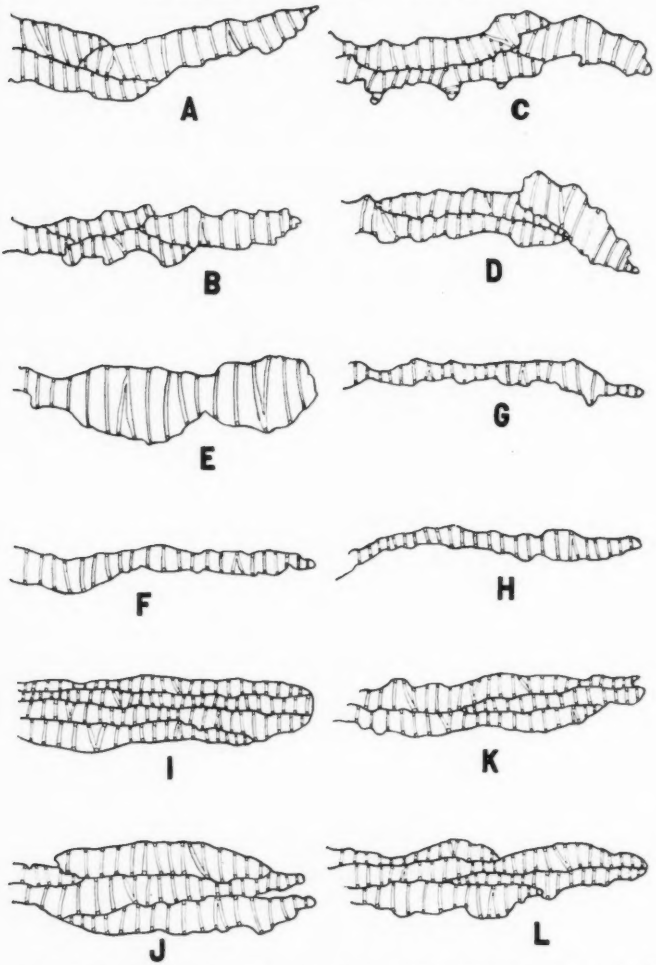

Plate XI. Multiple veins ending in a single tracheid. x440. A, from *Lathyrus sp.* B, from *Catalpa speciosa.* C, from *Rubus villosus.* D, from *Melilotus alba.* Single tracheid endings. E, from *Datura suaveolens.* F, from *Fragaria vesca.* G, from *Lathyrus ochroleucus.* H, from *Taraxacum officinale.* Multiple endings of three or more tracheids. I, from *Galinsoga parviflora.* J, from *Aster cordifolius.* K, from *Vicia cracca.* L, from *Liatris cylindracea.*

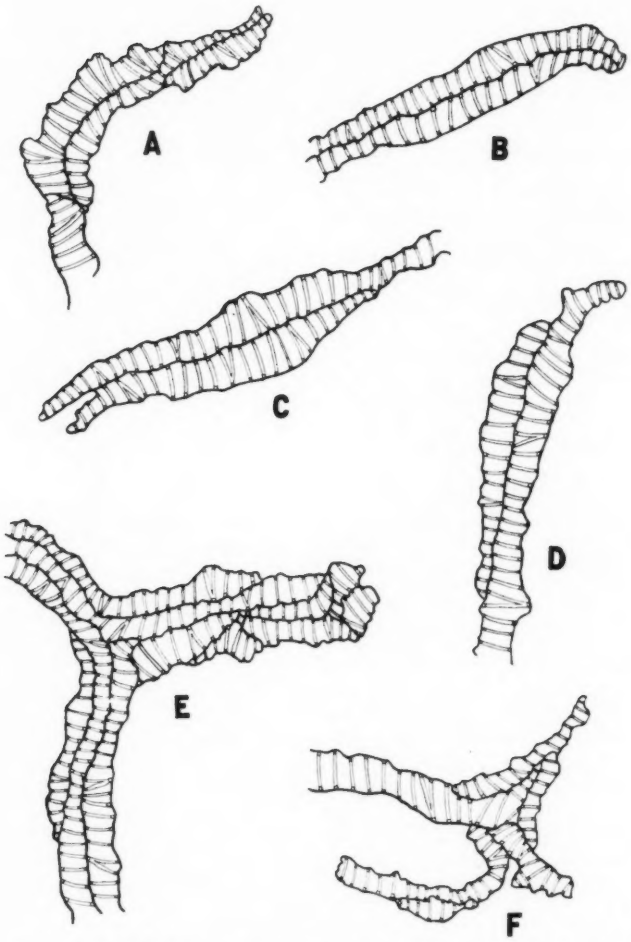

Plate XII. Multiple endings of two tracheids. x440. A, from *Lathyrus maritimus.* B, from *Sorbaria sorbifolia.* C, from *Helianthus divaricatus.* D, from *Sambucus canadensis.* Multiple endings composed of irregular, triangular tracheids. E, from *Vernonia sp.* F, from *Lupinus perennis.*

BOOK REVIEWS

THE MECHANISM OF CREATIVE EVOLUTION, by C. C. Hurst. The University Press, Cambridge, and the Macmillan Company, New York, 1932. xxii + 365 pp., 198 figs. $6.00.

Books on genetics are so numerous and so repetitious that the historically-minded biologist views new ones with skepticism. Is there any value in repeating, apparently *ad infinitum*, the facts of dominance, linkage and Mendelian ratios, all of which already are well stated? May not abundant new terms (on which Walter has made properly humorous comment) conceal much more than they explain? And do not increasing certainty and inclusiveness of assertion indicate the growth of a dogma whose chief basis is over-confidence? One does not readily forget that the foremost American geneticist has used "The Scientific Basis of Evolution" as title for a volume which contained little but a resume, yet ignored biogeography, paleontology and much of embryology, while apparently giving tribute to Darwin.

To those who have reached a somewhat hostile skepticism, Hurst's book comes both as refutation and confirmation. Though it restates familiar essentials of genetics, it does so in an original and stimulating way. It frankly admits the difficulty of some problems, shows a rare breadth of interest, and relates genetics to past aspects of evolution—a task avoided by most of its rivals. And though anything but an elementary treatise, it is so written that the systematist, or geologist, or paleontologist, may read it without constantly breaking his thought to seek for definitions not given, nor implied.

Though he borrows the term creative evolution from Bergson, Hurst provides it with biologic meaning. He points out that in biologic processes 2 and 2 give, not 4, but a sum unpredictable in amount and quality, and hence best represented by the symbol X. In this, he links himself with proponents of emergent evolution—with the difference that he assigns much greater importance to the unpredictability of X. Indeed, he is so much impressed that he allows it to lead him into prediction, and in a final chapter on "Speculations" announces "that in the course of long ages and perhaps several great creative steps, successors to man will be evolved in whom the influence of matter has been almost, if not entirely, obliterated, and a sub-material type of being will arise" able to swing through space in the stellar galaxy for visits to other organisms of "pure thought or spirit . . . who may exist in other parts of the universe as a product of creative evolution in other planets."

Such a concept does not demand attention in a journal devoted to natural science, but one may examine its basic assumption. Though widely made by geneticists (who thereby link themselves with an

earlier school of heterogeneticists), it has not convinced students of fossils. From long experience, they know that X often can be predicted: that from a given series of fossils one may outline a later genus or species, and determine at what level to seek it. They also know that the problem may be worked in reverse order, which would be quite impossible if X really were different in form and quality from the stages that have preceded it. Every paleontologist engaged in tracing phyletic series has thus "predicted" unknown members, which he or later paleontologists have found; and it will take much more than the assertions of genetics to dispose of the fossils thus discovered. In a slightly different guise, the problem has been met by Haldlane, who admits that he has no ready answer. Hurst ignores it, and follows the easy, Morganian procedure of calling orthogenesis a mystical theory. Aside from the fact that such condemnation comes strangely from the author of the "speculations" just mentioned, it is largely untrue—as reading of Buffon and Eimer would have shown. Genetics often displays too great willingness to dismiss without study the works of early biologists, even while erecting into an essential law of nature the principle of natural selection. One is glad to see a retreat from the over-confident negation of Pearl; but may not Hurst be equally in error in too ready acceptance of modern natural selection, as set forth by Fisher, Haldane and Wright?

Nor is it clear that genetics is all on the side of heterogenesis. Hurst leans heavily on the work of Vavilov—but that emphasizes the development of homologous series in both related and unrelated groups: essentially the orthogenesis of paleontologists, as I have shown in my *Studies of Evolution in the Genus Spirifer*. In spite of Hurst's use of them, my own opinion remains that Vavilov's papers (four of which are listed in Hurst's excellent bibliography), form an important contribution to the study of limited, as opposed to promiscuous variation, and contain much of value to paleontologists.

How much those paleontologists can gain from Hurst's genetic definition of a species as "a group of individuals of common descent, with certain constant specific characters in common which are represented in the nucleus of each cell by constant and characteristic sets of chromosomes carrying homozygous specific genes, causing as a rule intra-fertility and inter-sterility" remains to be seen. Cockerell (Science, vol. 77, p. 90, 1933) has remarked that it will unite rather than divide species, and some members in the unions will be very unlike. The paleontologist can determine genetic constitution only by somatically-formed characters; it is not probable that Hurst's concept will give genetic significance to even such inclusive "species" as *Atrypa reticularis* of most authors.

Interesting suggestions lie in the pages devoted to bacteria, to genes, and to hypothetical progenes. Is the bacteriophage a free gene?

Its size renders such a speculation possible, as do the most minute viruses. It is interesting to find Hurst using Haeckel's term Protista,

though for organisms much smaller than those for which it was devised. Those who like to speculate on the conditions of life during Archaeozoic ages will find the pages devoted to the gene as a basis of organic complexity interesting, if not finally reliable. And if of Buffonian tendencies (most of us erroneously call them Lamarckian!) they will find the account of induced mutation reassuring, even though Muller does appear as Müller, and much reliance is placed on natural selection. It is puzzling that geneticists show such concern for that theory, when much of their work seems to reduce its importance. Yet again and again they drag it forth—though Hurst does once join H. S. Williams in characterizing it as a stabilizing, not a modifying factor.

Of more concern in the history of organisms, is the growing realization that genetic situations can allow both for conservatism of type, and disintegration from complex to simple. "Experiments," says Hurst, "show that simple diploid species are alone able to give complete expression to all their characters, each being specialised and adapted to occupy a peculiar niche of its own in nature, whereas the complex polyploid species is more generalised in its characters and habits, being able to adapt itself and survive under adverse conditions where the specialised diploid species would perish." One hopes for genetic analysis of *Plumatella*, *Limulus*, *Lingula* and other examples of what Ruedemann calls "arrested" evolution, in order to see how extensively these experimental results may be applied to life's history. Certainly they cannot be general, for (as Hurst says) five surviving genera of apparently Miocene roses are without polyploid members. But since time since the Miocene has been much shorter than that since *Limulus* made its appearance, the survival of these diploids is not surprising.

Thus the book contains many suggestions for the paleontologist as well as for the student of living organisms. Hence one regrets that it contains errors sure to arouse the antagonism of paleontologists, who naturally dislike to find their facts mistreated, and doubt the reliability of those who thus treat them. Surely it would not have been hard for Dr. Hurst to learn that the "famous Canyon of Colorado" is dug in rocks of Paleozoic age and older, and so could not possibly contain the series of horses that he specifies on page 315. Specimens in Cambridge and the British Museum should have prevented the assertion that horned and armored dinosaurs fell "easy prey" to the "ancestors of our present-day mammals." Lull has dramatically illustrated the difference in size and ferocity between dinosaurs and Mesozoic mammals; now paleontologists who are tired of crossword puzzles may exercise their minds to discover the means by which those tiny mammals killed *Stegosaurus* and *Triceratops*. Or they may try to assimilate a time-scale which runs: Azoic, Eozoic, Proterozoic and Late Pre-Cambrian, especially if they join Professor Daly in putting the late Proterozoic strata into the Cambrian system.

Dr. Hurst, in short, has permitted himself to be careless in a field where, as an evolutionist, he should observe caution and seek significant knowledge. He also has allowed his enthusiasm for a generalization that is dubious at best, to lead him into speculations that are neither philosophy, theology nor science. They mar a book that is one of the best in its field, and strengthen the fear of adherence to dogma that was mentioned in my first paragraph. Yet they do not deprive the book of its value, since they affect chiefly the last twenty-seven pages, which one my disregard if he will. Through page 314 the book is one of significance and stimulation, for all who deal with processes and history of life. Henry Shaler Williams often urged geologists and paleontologists to give greater attention to biology. The advice still is timely, and *The Mechanism of Creative Evolution* serves to give it point.—CARROLL LANE FENTON.

OUR STONE-PELTED PLANET, by H. H. Nininger. Houghton, Mifflin Company, Boston and New York, 1933. xxvi + 237 pp., 60 illustrations. $3.00.

A compact, popular yet dignified account of meteors and meteorites, written by a collector and curator in the Colorado Museum of Natural History. It discusses the nature and significance of these bodies, especially as illustrated by important falls; it catalogues those falls for the world, and locates them on convenient outline maps. A good deal of space is devoted to the discovery and proper recording of falls: for as Mr. Nininger says, farmers and ranchmen are much more apt to find meteorites than are the men who eventually will study them. Unless scientists try to interest those farmers, real meteorites will continue to be discarded while curators will be plagued with endless pebbles or slag or granite which the curio hunter holds to be precious.

Perhaps the most surprising information in the book is that which shows that meteorites were denied existence until well into the nineteenth century; that perhaps the most significant of recent falls (that of Siberia, in 1908) was and still is ignored by most scientists. If meteorites are worthy study at all, they seem to deserve more than casual attention or undernourished expeditions that fail because of insufficient money.

In view of recent controversy over Meteor Crater, reference to similar structures in Australia, and one of the Melton-Schriever photographs of meteor scars in South Carolina are specially appropriate. Thus the book is irreproachably up-to-date, praise that can not always be given a popular production.—CARROLL LANE FENTON.

FRESH-WATER ALGAE OF THE UNITED STATES, by Gilbert S. Smith. New York and London: McGraw-Hill Book Co. 1933. xi +716 pp., 449 figs. $6.00.

The selection of organisms to be included in a treatise on algae must of necessity be made arbitrarily according to the author's concept of the plant kingdom. In a natural system of classification *Algae* cannot be regarded as a particular subdivision of the plant kingdom, but rather as a heterogeneous assemblage of simple plants, the various series of which show evidence of having been derived from ancestors quite different from one another. The term 'alga,' then, becomes one of convenience only, including those pigmented protista of both flagellate and algal organization (as it is impossible to consider one without the other) which are believed by the author to be more plant-like than animal-like. Professor Smith, for example, excludes the *Cryptophyceae*, accepted by several algologists, from this work because "it is . . . questionable whether the *Cryptophyceae* should be considered a series in which an algal organization has been evolved."

Nine phylogenetic classes are recognized in this book. Following Pascher and Fritsch, Professor Smith makes it clear that the algae must be separated into a number of divisions of coordinate rank with the Bryophyta and Pteridophyta. Some of the nine series are themselves sufficiently distinct from all others as to warrant being considered as a division of the plant kingdom. Others show relationships among themselves so as to be included together under one division. Professor Smith's classification of *Algae* follows:

Division I.	Schizophyta
Class 1.	Myxophyceae
Division II.	Rhodophyta
Class 2.	Rhodophyceae
Division III.	Chrysophyta
Class 3.	Heterokontae
Class 4.	Chrysophyceae
Class 5.	Bacillarieae
Division IV.	Phaeophyta
Class 6.	Phaeophyceae
Division V.	Chlorophyta
Class 7.	Chlorophyceae
Division VI.	Pyrrophyta
Class 8.	Dinophyceae.
Of uncertain systematic position:	
Class 9.	Euglenophyceae.

It should be noted that Professor Smith has placed the *Rhodophyceae* immediately following the blue-green algae and calls attention to their similarities in having red and blue pigments in their protoplasts,

in their primitive type of nuclear division, and in their lack of motile reproductive cells.

One wonders what is to be done with the *Charales*, which are omitted from consideration here, especially in view of the discussion of the relationships of the algae to the Bryophyta, Pteridophyta and Spermatophyta without finding a place, apparently, for this puzzling but very real group of plants.

In Chapter I (Introduction) are included the following topics: Environmental Factors Affecting the Growth of Algae: Algae of Different Types of Habitat: Algae of Unusual Habitats: Periodicity of Fresh-Water Algae. The discussion of Collection, Preservation and Methods of Studying the Fresh-Water Algae will be of interest to all students of this group. The treatment of each of the eight classes included in this text (*Phaeophyceae* being omitted) is quite uniform. An introduction, in which are discussed such topics as nature, occurrence, organization of the plant body, cell structure, reproduction, relationships, classification, is followed by a consideration of genera and species of that class represented in the fresh-waters of the United States. There are many keys to the genera of families, and in the majority of instances all the known American species are listed.

The book is profusely and excellently illustrated with the majority of figures original. As a further aid to the student there is appended a comprehensive key to some 430 fresh-water algae, based as largely as possible on vegetative characters. Students of algae will find this volume of real value.—J. H. HOSKINS.

TRAITÉ D'ALGOLOGIE, by Pierre Dangeard. Encyclopédie Biologique XI. Paris: P. Lechevalier & Fils. 1933. 441 pp., 380 figs. 175 francs.

The sub-title of Professor Dangeard's book, "Introduction to the Biology and Classification of the Algae" describes very accurately the scope of the work. It is a general survey of both marine and fresh-water forms, with chapters on Cytology, Physiology, Sexuality and Alternation of Generations lending strength to the book.

Professor Dangeard considers the algae under the following ten classes, to which, for the sake of uniformity, he has given comparable name-endings: Chrysophyceae: Flagellophyceae (Chloromonadinae and Euglenidineae): Dinophyceae (including Cryptomonadineae): Bacillariophyceae: Xanthophyceae (Heterokontae): Chlorophyceae: Charophyceae: Phaeophyceae: Rhodophyceae: Myxophyceae.

With the exception of the first, each of the twenty-two chapters is followed by a well selected bibliography frequently separated into sections for specific algal groups. The illustrations are good and have been carefully selected with many originals. The volume is brought to a close with a very short chapter on Fossil Algae which might well have been somewhat expanded.—J. H. HOSKINS.

A NATURALIST IN THE GUIANA FOREST, by Major R. W. G. Hingston, M.C., M.B., Leader of the Oxford University Expedition to British Guiana. 8vo., 384 pp., 16 pl., 150 text illus. London. Edward Arnold & Co., 1932, 18 shillings.

This volume outlines a method of research which undoubtedly breaks the trail for much more important biological work to be performed in the future along a similar intensive line. It is not merely a collecting expedition to bring back a vast host of specimens later to be worked up, nor does it require a long and dangerous trek filled with hardships through hitherto unexplored territory. It is a narrative of studies by a group of trained naturalists who settled for awhile in the midst of a little known region, and brought all their previous experience and powers of observation to bear upon the study of the jungle creatures in their native haunts. These scientists were sent out under the auspices of the University of Oxford Exploration Club and prepared a comfortable camp for themselves in a jungle on a side creek of the Essequibo River in British Guiana. Here they devoted a prolonged period to a most detailed study of the various forms of life including birds, insects and plant life, in the midst of which they were placed.

The book is divided into two sections. The first furnishes a general narrative occupying approximately one-sixth of the volume devoted to details of travels, to locating camp, to a narration of methods used and difficulties encountered in the investigation, to a brief summary of their observations on forest and animal life, and particularly to an account of their unique exploration of the tree-tops. The second and larger part of the book deals with details of the natural history of the insects, spiders, and other various living forms, their nests and snares and their protecting and intimidating devices, illustrated with unusually clear and excellent drawings prepared by the author. A larger section is devoted to especial studies of spiders, their protective devices in cartwheel snares and snares in relation to concealment, devices for securing protection, interesting and unusual snares, and the various forms of nests of tropical spiders. Major Hingston has included in an appendix to the volume descriptions of some twenty-seven new species of spiders. Considerable attention also is given to record of observations of tropical insects, and of their intimidating, warning and protecting devices. Much information also s igven on ants and termites, and entire chapters are devoted to studies of caterpillar cases and nest suspension as a mode of defence.—J. S. WADE.

THE BIRDS OF OKLAHOMA (Revised Edition) by Margaret Morse Nice. 8 vo., 224 pp., 12 figs. Norman. University of Oklahoma Press, 1931. $1.00.

The plan of this work is to present a summary of the knowledge thus far obtained on the subject rather than details of life-history or minutiae. There are sections treating on the past and present in Oklahoma bird life; physical features of the State; breeding birds; winter bird life; migrations; attraction and protection; suggestions as to most useful bird books and magazines; itineraries and reports of field workers in the State; the list of birds comprising 142 pages; and a bibliography of Oklahoma ornithology consisting of 313 titles. There are outline maps showing physiographic and vegetational regions, and an historical map showing the various sections of the State in relation to the work of the early ornithologists. An unusually workable index is appended.

In the list of birds there are 385 species and subspecies, 334 being full species. Nineteen species have been admitted on slight records. Thirty-five new forms have been added in the last seven years; thirty-three of these are transients or winter visitants, two are new subspecies of breeding birds. Seventeen are new species, eighteen new subspecies of forms already known to occur. Of the 385 birds credited to the State, 95 are residents, either nonmigratory birds nesting in the State or migratory birds occurring in both summer and winter; 114 are summer residents; 64 are winter visitors, 108 spring and fall transients, and four of casual occurrence.—J. S. WADE.

LOUIS AGASSIZ AS A TEACHER, by Lane Cooper. x + 74 pp. 12 vo. cloth. Ithaca N. Y. Comstock Pub. Co. 1st ed. 1917. 2nd ed. 1932. $1.00.

It is the purpose of this work to present the actual methods used by one of the world's foremost men of science in development of teachers and scientific investigators. Formerly out of print it is fortunate because of its usefulness that the book has again become available for it depicts realistically the great naturalist at work as it were in a succession of living pictures. In addition to a sketch of the life of Agassiz the volume includes four accounts by four former pupils, who subsequently became famous, Shaler, Verrill, Wilder, and Scudder, of the details concerning the procedure used by him in aiding them, and there are given in their own words the process by which they were led really to observe the forms of nature, as birds and fishes, through direct and independent observation.—J. S. WADE.

HANDBUCH DER SYSTEMATISCHEN BOTANIK, by Richard Wettstein. Leipzig and Vienna, Franz Deuticke, 1933. 4th revised ed., Vol. I., x+537 pp., 335 figs. and 3 diagrams.

Prof. Richard Wettstein's life-work appears after his death, the difficult task of finishing it having been left to his son Prof. Fritz v. Wettstein. The latter successfully revised the greater part of the "Handbuch" following his father's wishes and proposed changes.

The outstanding feature of this edition is the rearrangement of the phyla usually considered as Thallophyta. 9 phyla, in all, are recognized, some of which appear new while others were differently circumscribed. They are as follows: (1) Schizophyta, (2) Monadophyta (comprising all flagellates of plant-like organization), (3) Myxophyta, (4) Conjugatophyta, (5) Bacillariophyta, (6) Phaeophyta, (7) Rhodophyta, (8) Euthallophyta, (9) Cormophyta. The classification of each of these phyla has been subject to thorough revision to conform with our present status of knowledge of the groups as interpreted by Wettstein. It is the privilege of the author to read the suggested phylogenetic lines of development in his way, often differing from others, yet is suggestive in its own right. Though the volume presents a wealth of information of subject matter its prime mission was never to compile available data but rather use them as a means in the approach to a phylogenetic classification of the whole plant kingdom, which is the ultimate goal of botanical investigation. A comparison of the different editions will immediately reveal the author's own recognition of the imperfectness of such undertakings as illustrated by the continued changes brought about by further detailed researches. Since fully recognizing this progress in the advance of our knowledge and utilizing it continuously he found himself open to these new views, thereby avoiding any dogmatic method of presentation. However once convinced of the correctness of his interpretation he firmly maintained his position. It is this character that made Wettstein one of the most prominent figures in the development of a phylogenetic system. His careful analysis combined with his unusual capacities for seeing the great developmental lines gave this work its originality and permanent value. His broad experience with every group in discussion allowed him to advance with force views challenging many old conceptions. It will be the task of future work to prove or disprove the arguments proposed and to mellow the wide differences of opinion still prevailing.

While revisions necessarily had to be made in various parts of the work its general character has been left preserved. In this respect it will continue to represent the testimony of a great mind to his fellow men.—TH. JUST.